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The Journal of
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from the editor . . .

For reasons that must be obscure to even the most optimistic among us, the beginning of the new year always brings with it a degree of hope. For those involved in the business of providing for and maintaining the national defense, part of that hope is no doubt related to the ushering in of a new administration that promises a changed perception of the role of the military and of the real resources required to fulfill that role. But those of us who wait for substantial increases in defense spending or other quick-fix solutions to relieve us of the challenges of efficient resource management are waiting for a ship that will never come in.

There may, indeed, be real increases in defense spending. There may be a more sympathetic hearing given to the military in its requests for more and better instruments of war (or, more accurately, of peace). There may even be a lessening of the tendency within the legislative branch to bill defense for the cost of social programs (along with the recognition of defense itself as the ultimate social program).

But these changes, if they do come, will bring little relief for the front-line acquisition manager. There will be no relaxation in the pressures to get new systems into the field more quickly, or to do a better job of cost estimating (the theme of the Spring 1981 issue of *Concepts*), or, most importantly, to make those tough decisions about the kind of new hardware we need and the way it should be used. In fact, these pressures will likely become even more intense as more and more emphasis is put on military force as an instrument of foreign policy. This emphasis will demand an evermore capable and ready military force which, in turn, will demand an evermore capable and ready cadre of competent, trained, and experienced acquisition managers.

So, as we anticipate the new decade under new political leadership, let's not lose sight of the never-ending challenge that lies ahead for the military acquisition manager. And let us not think for a moment that optimism alone will suffice. Good, effective, efficient management is the only answer, an answer to which the Defense Systems Management College is dedicated to providing.

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Technology: Our Only Escape from the 'Good Old Days'

Lieutenant General Robert T. Marsh, USAF

Judging from what the news media are telling us, the avionics world has gone completely to pot. It's being said that our aircraft are being built so technologically sophisticated that they spend more time in the repair shop than in the air. Those of you who suffered through the recent "20-20" television show which echoed these charges would certainly have been left with the impression that we've become so obsessed with technological gadgetry, that we've forgotten about the practical world.

It's interesting to compare this criticism of our efforts, to make advanced technology workable, with the early days of the space program. One of our attempts to put a satellite in orbit resulted in an altitude of six feet. Yet in those days, there seemed to be an acceptance of the fact of risk in sophisticated undertakings. But those were different times. I don't want to sound paranoid, but it's a fact of life that the Department of Defense is being examined as never before at all levels, and under a high-powered microscope.

Critics are prone to equate one dollar for defense as one dollar less for social programs or for tax reform. They expect every military technology dollar to produce instant, unqualified success according to a milestone schedule that forecasts the month—if not the day and hour—when scientific breakthroughs will be made. These attacks may be more a criticism of technology in general than of individual organizations or their products. If so, charges mirror a distrust of technology that's not altogether unfounded. In medicine, last year's miracle cure may turn out to be the cause of this year's illness. Your new car is the latest and greatest achievement of Detroit's automotive genius—but it gets recalled because of a tendency to lose the fuel line while going 55 down Route 444. Your instant-on television seems to be a real blessing—you won't miss the kickoff waiting for it to warm up—and then it sets your living room on fire.

Editor's Note: This article is adapted from a presentation by General Marsh to the Avionics Laboratory, Wright-Patterson AFB, Ohio, in June 1980.

Lieutenant General Robert T. Marsh is Commander, Electronic Systems Division, Air Force Systems Command. Previous assignments include duties as Project Officer, NAVAHO and MATADOR/MACE; Staff Officer and Executive Officer in the office of the Deputy Chief of Staff for Research and Development; Deputy for Reconnaissance, Strike and Electronic Warfare (AFSC); Deputy Chief of Staff for Development Plans and System (AFSC); and Vice Commander, Air Force Systems Command. Lt. Gen. Marsh holds degrees from the U.S. Military Academy and the University of Michigan.

Different Outlooks

Yes, it's understandable that some look at the advances of technology with a jaundiced eye, or even with a feeling that somewhere in a dark laboratory, a modern-day Dr. Frankenstein is creating a new monster to unleash amongst us. It's understandable that some critics want a return to simpler times, perhaps not all the way back to leather helmets, goggles and a long white scarf, but at least part way.

Keeping our advanced avionics in peak condition does indeed put strong demands on our maintenance personnel. Admittedly, we do face serious problems in the retention of well-trained, motivated personnel with the current pay levels. In some ways, our training programs for electronics technicians amount to prep schools for industry, where much more attractive salaries are being offered. Nonetheless, it's hard to picture just how a modern air arm could operate without a full range of avionics available to us. Can you imagine what it would be like to attempt a low-level run in a jet aircraft—200 feet off the deck with stationary and very solid objects closing at nearly 900 feet per second—and you have to decide how to maneuver to avoid boring holes in the terrain while still keeping the wings attached?

Attempting that without a full load of top-notch avionics is about as sensible as going one-on-one against a MiG with a tube sticking out in front of your cockpit as a gunsight. Trying to adjust for "Kentucky windage" at better than Mach 1 wouldn't do much for your longevity prospects. Or in conventional bombing missions, should we be content with the World War II tactic of dropping hundreds of bombs in the hope that a few would come close to what we were really trying to hit? It is a simpler way to try to do the job, and if you want to compare the cost of a guided bomb, along with the electronic system to guide it to the target, to the cost of the bomb that follows winds and gravity to a target, then certainly the one that just falls is cheaper on a per-item basis. But, ask any pilot who had to hold a steady course in an attempt to hit a heavily defended bridge, and he'll tell you what guided munitions mean to him, and would have meant to those fellow pilots who never made it back.

How about airborne reconnaissance? Should we scrap our efforts in radar, infrared, and laser imaging in the name of simplicity? Certainly we could buy a lot of convenient RF-4 cameras for the price of a Loreors. But, recall one wartime experience with "simple" reconnaissance—the Battle of the Bulge in World War II—the worst experience we suffered in the land campaign in Europe. Here, Allied airpower had swept the skies virtually clear of enemy aircraft. We could fly over German territory with near impunity, see whatever troop movements were in the works, and respond to any choice targets.

The Unknowns

So what happened?

The weather was bad, an unfortunate, though routine, happening in Central Europe. Our knowledge of enemy movements depended upon eyeballs and ordinary photographic film. Faced with fog and clouds, our airborne reconnaissance might as well have been on the wrong side of a cement block wall. As a result, we were caught by surprise. And not until the weather cleared and our formidable airpower advantage was put back into play were we able to push the enemy back and continue on the road to Berlin.

Or take the electronic warfare area—where would we be without the latest technology there?

The answer is, perhaps, in the same condition that Israeli pilots found themselves in combat in 1973. Then, the Arab forces were able to jam the Israeli electronics as their aircraft began to roll down the runway. Once airborne, the pilots were in an "every-man-for-himself" situation, without ground guidance and unable to talk to other pilots who might be flying only feet off their wingtips. The immediate result of this electronic warfare was to negate the effectiveness of the Israeli air force.

The sentiment for "the good old days" surfaces in arguments for desophisticating our interceptor force into simple, lightweight day fighters—buying a lot of cheaper aircraft with less complex avionics. This argument cites reports of tests where the relatively inexpensive and uncomplicated F-5s did well in simulated combat against our newer fighters—under certain conditions. There's the rub—under certain conditions. Unfortunately for our pilots who may be called to put their lives on the line, battle conditions are not open for negotiation. It would certainly make the defense planner's job much easier if he were sure that from now on, combat would only take place between the hours of nine and five and on clear days. That's hardly the real world. We must be prepared at all times for all eventualities. The real world demands much more than a sunshine Air Force. The tactical air forces realize this best of all. They make no bones about their most pressing need—it's for an all-weather capability.

The tactical mission calls for very low-level flying so that defenses won't have time to react, but at the same time, making sure that what we think is an enemy really is, and then somehow getting the armament on target. That's a lot to ask for in what is generally a one-man operation; yet, on top of this, the pilot must keep from getting shot down or from flying into the ground. And he must do this on moonless nights in pea-soup fog.

It's obvious that returning to the "good old days" won't give us the capabilities we need if the Air Force is to be a credible instrument of national

policy. And that's key, for otherwise our nation will find itself without any blue chips when it sits down to the international bargaining table. The simple fact is that we have no choice when it comes to technological sophistication. Someone recently commented that our military requirements are drawn up in the Kremlin. In a sense, that's true; we have to meet every threat and keep one step ahead of our potential enemy.

Keeping Ahead

In keeping ahead, we in the electronics field find ourselves with a sort of "embarrassment of riches." Technology is exploding in all directions, with attractive-sounding options. One estimate of this explosion is that there will be a complete turnover of technology every 3 to 5 years. That's fast. It means that more worthwhile projects are being proposed than possibly can be funded. This squeeze makes it very hard for us who manage technology to do our jobs, and it makes it especially difficult for defense planners, who are supposed to be looking out years ahead, to do theirs.

But the payoff for successful basic advances is well worth the investment. Take for example the integrated circuit, which already has made it possible to hold in your hand the computational power that 20 years ago would have required a roomful of vacuum-tube equipment. The "next generation" from that—very high speed integration—also promises a great payoff that will be reflected in consumer as well as military products. In one program under my direction, the joint tactical information distribution system, which promises to revolutionize military air, ground, and sea communications, it has been estimated that this development will reduce the current equipment weight from 80 down to 10 pounds; cut the size from a foot-and-one-half cube to about that of a child's building block; drop power requirements from a thousand watts to that of a common light bulb; give us mean time between failures of years instead of hours; and reduce costs by a factor of 15 or more.

Those of you who may have followed the progress through Congress of the funding for this very high speed integration technology know that it had more cliff-hanging escapes than The Perils of Pauline. I think it's a prime example of the problems we all are facing in getting scarce defense dollars for technology.

But it seems to me that the only way to get the most for our defense budget is to harness technology so that, with skill and precision, we can overcome the threat of sheer numbers of opposing forces. In today's military world, numbers are exactly what the Free World is up against. It is especially true in Europe, where we cannot hope to outnumber our opponent. In men and tanks, the "bottom line" in ground warfare, we face deficits of four or five to one.

To overcome this numerical disadvantage, we look to technological advances to act as force multipliers, allowing us to get the most effective use of our limited resources by applying the right force at the right time in the right manner. For when you come right down to it, military resources that are badly used are the same as no forces at all. History, time and again, has given the lesson of how David slew Goliath—of how numerically small forces, thanks to more effective use, defeated superior numbers.

What now is being done in avionics has a significant role in adding the force-multiplier factor to the defense equation—better ways to communicate, better ways to deliver weapons.

Helping Commanders

This is what the Electronic Systems Division is doing in its force-multiplier role of helping commanders make the best use of their forces.

For example, we address the needs of a commander in Europe, deep inside an underground concrete bunker, secure from attack, witn electronics as his eyes, ears, and voice. His only contact with the real world comes from lights on display screens or disembodied voices over speakers.

So it is with our pilot in that typical European pea-soup fog, who must trust his instruments and his friends tracking him from the ground. The pilot's instruments constantly sample his environment and his aircraft, reducing thousands of data points into a pointing needle or a glowing light. The pilot doesn't need to know every detail about his aircraft, just as the mountain-based commander doesn't need to know every detail about, for example, what aircraft his radars are tracking. But he does need to know what's important—such as suspicious aircraft entering friendly airspace.

For this, the commander relies on the computer to sift out significant information from all the inputs and bring it forcefully to his attention, just as a pilot about to land needs an abrupt and forceful warning from his avionics systems that his landing gear is still up—he really doesn't need to know much more than that.

At this point the commander, should action be needed, again can call upon his electronic aids to tell him precisely what forces he has at his disposal at that moment; he can direct their use and get reliable feedback on what's happened so he can plan his next move.

That's how the electronic force multipliers could act on a small scale. Expand that snapshot to include those commanders who must act on a global scale, and you can begin to appreciate just how much technology is needed so that they can function efficiently.

The force-multiplier concept doesn't apply just to operational units. It reaches us even in Systems Command, into how and what we do. For, just as operational commanders have to make judicious use of their resources, so do we use the same type of information flow in carrying out our research, development, and acquisition mission.

Things that seem light-years from the operational Air Force, such as finding ways to cut down on unnecessary contractor data requirements, or fine-tuning the procurement system so that work is definitized quicker, or ensuring that a line of research isn't duplicating something that's already been done; these also have a force-multiplier effect in making sure that we get the most out of the defense dollar and that the man or woman in the field can do his or her job with peak effectiveness.

Bridging the Chasm

This calls upon us, the innovators and suppliers of new technology, to bridge what sometimes amounts to a chasm between what is possible and what is *practical*. Our high technology products must be not only affordable; they must also be reliable, so that breakdowns are minimized; maintainable, so that a graduate degree in electronics isn't required to fix them when they break down; and supportable, so that we don't have to carry a warehouse full of tools, test equipment, and specialized parts wherever we go.

This technology doesn't come cheap. It costs, and it bears repeating that we just can't afford everything. That's a lesson all of us who spend any time in the R&D field learn early in our careers. I'm sure that many of you know the frustration of working on a project you know will solve some pressing operational need only to have the rug jerked out from under you by a lack of funding.

We are in a very tough period as far as money is concerned. The inflation taking a bigger bite out of your pocket every time you go to the store has the same effect on the Department of Defense when it goes to the technology supermarket. Difficult choices are being made now in the 1982 program objectives memorandum, and you shouldn't think that avionics is being singled out for cuts any more than I will feel slighted when I see what the budget planners have allotted my programs.

The only thing to do is fight the good fight for what you think is important, and then do your best with what is authorized—without looking back on what might have been. ||

13 Improving the Acquisition System

Dr. Robert J. Massey
Gordon A. Smith
Jack F. Witten

This is not a conventional report on research, but rather a proposal for action to apply some of what we already know in an effort to bring the acquisition system under control and to rationalize its operation.

We contend that "the system" is out of control. It has become a monster that is threatening efficient accomplishment of the acquisition function in government. Under "the system," acquisition (1) takes too long, (2) costs too much, and worst of all (3) taxes away too much of the time and energies of the limited supply of people who are capable of contributing effectively to technological innovation.

This situation is not inevitable. We have the tools in hand, now, to bring the system under control and drastically improve the effectiveness and economy of government acquisition.

We do not have research-based statistical proof of the charges we have made. But, we know they are true because we have experienced the system, each from a different perspective. Further, we are not alone in our concern with the cost and effectiveness of the acquisition process.

Is the System All That Bad?

In the late '60s, the Blue Ribbon Defense Panel studied the acquisition process. Its Chairman, Gilbert Fitzhugh, characterized the system this way:

> Everybody is somewhat responsible for everything, and nobody is completely responsible for anything. So there's no way of assigning authority, responsibility and accountability. You can't hold anybody accountable. There is nobody that you can point your finger to if anything goes wrong, and there is nobody you can pin a medal on if it goes right, because everything is everybody's business, and as you know, what is everybody's business is nobody's business.

Dr. Robert J. Massey, a former Navy lieutenant commander, heads Progress Management Services, Arlington, Va. He holds a B.A. degree from San Diego State University, and a master's and doctorate degree in public administration from the American University.

Gordon A. Smith is Director, Design Assurance Engineering at Fairchild Space and Electronics Company, Md., where previously, he held Director, Mechanical Engineering, and various program management positions. Prior to joining Fairchild in 1971, Mr. Smith held program management positions at MDAC, De Havilland Aircraft of Canada, and the British Aircraft Corporation. Mr. Smith holds a B.S. degree in mechanical engineering, an M.S.A. from the George Washington University and is a doctoral candidate at G.W.U.

Jack F. Witten is a Progress Management Services Associate. He was the first Technical Director of the Naval Air Integrated Support Center at Patuxent River, Md. Mr. Witten retired from the Civil Service in 1975 after serving in positions related to modification, maintenance, and logistic support of naval aircraft.

> They spend their time coordinating with each other and shuffling papers back and forth and that's what causes all the red tape and the big staffs in the Department. Nobody can do anything without checking with seven other people.[1]

David Packard, co-founder and Chairman of the Board of Hewlett-Packard Corporation, did battle with the system when he was Deputy Secretary of Defense in the late '60s and early '70s. In an address to the Armed Forces Management Association in 1970, Packard remarked:

> I have been in this job now for 19 months. Frankly, I am ashamed I have not been able to do very many of the things that need to be done to improve the situation I found here in January 1969. The most frustrating thing is that we know how we ought to manage—you, me, all of us—and we refuse to change based on what we know. Every time we want something done in a hurry and want it done right, we have to take the project out of the system. We give a good man direction and authority and let him go—and it works.
>
> On the other hand, when we are not in a hurry to get things done right, we over-organize, over-man, over-spend and under-accomplish. The most dramatic contrast is within Lockheed. Kelly Johnson and his programs, and the Air Force and Lockheed on the C-5A. I simply cannot understand why we are unable to change the system to avoid the C-5As and get more Skunk Works.
>
> In one case, a small dedicated Air Force team developed the gunships which have been so successful in Vietnam. The Air Force decided to put this program into its formal system. About a month ago I asked when we would be able to get some more gunships. The answer was in two years. That program is now out of the Air Force system, and we will have more gunships in six months.[2]

The RAN/D&F Ritual

We have contended that the system is consuming our substance and is out of control. Let us illustrate using the case of the "ritual" of the request for authority to negotiate (RAN) and determination and findings (D&F) for procurement of R&D.

The procurement laws and regulations prescribe "formal advertising" as the

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1. Gilbert W. Fitzhugh, Chairman, Blue Ribbon Panel, remarks at Pentagon news briefing, 27 July 1970.

2. David Packard, Deputy Secretary of Defense, address to the Armed Forces Management Association, 20 August 1970.

basic means of federal procurement. All procurement not accomplished by formal advertising is considered procurement by "negotiation," regardless of how much competition may be involved. Under formal advertising, sealed bids are submitted, publicly opened, and the contract awarded to the lowest bidder.

If procurement is to be by formal advertising, it is necessary to define in advance exactly what it is the government is trying to buy. Thus, there is no way that R&D can be procured through formal advertising.

Since R&D can't be procured through formal advertising, the law permits procurement of R&D through negotiation. However, the law requires that a D&F, authorizing waiver of the formal advertising rule, be issued for each R&D procurement.

For all procurements of over $100,000, the D&F must be signed at the secretarial level. Almost never is the request for authority to negotiate flatly turned down, but a lot of people have died or retired during the time required to push the RAN through the endless layers between the levels where the government's work gets done and the offices of the Secretaries.

The cost of this ritual in man-hours and degradation of effectiveness through delay of business is enormous, but difficult to document in numbers. A senior official of the Blue Ribbon Defense Panel said the Panel identified an estimated 12,000 man-years a year in processing of RANs. If you consider 33 years as a typical federal career, then 12,000 man-years is the equivalent of 364 bureaucrat lifetimes sacrificed each year in this irrelevant ritual—the same as throwing a bureaucrat into the volcano each day except Christmas.

Looking at this ritual from the perspective of efficient acquisition, the Blue Ribbon Panel report of July 1970 observed that:

> The consequence of the statutory prescriptions and the D&F requirements place the officers of the Department of Defense in the position of being required to document and explain why they are using the most appropriate procurement method rather than an inappropriate one. The preparation, review, submisson and filing of the required D&Fs demand and receive a significant amount of personnel effort including that of the various Secretaries and Assistant Secretaries of each Military Department.[3]

Recommendation II-23 of the Blue Ribbon Defense Panel reads:

> The Secretary of Defense should recommend to the Congress and to the existing commission on Government-wide procurement that the Armed Services Procurement Act and other applicable statutes

3. Blue Ribbon Defense Panel Report, July 1970, p. 92.

> be amended to reduce or eliminate the requirement for Determination and Findings on all negotiated contracts, to reflect the practicalities of Defense procurement needs and activities which result in most Defense procurements being accomplished by other than formally advertised methods, and also to reflect the various new types of contracts developed in recent years.

One would think that should have triggered the retirement of that particular ritual, but two and a half years later, the Commission on Government Procurement report stated:

> When competitive negotiations are the appropriate procurement technique, the statute should not require Government officials to indulge in expensive, wasteful, and time-consuming procedures to carry out congressionally authorized missions.

In its formal recommendations, the Commission's recommendation 3(b) said:

> Authorize the use of competitive negotiation methods of contracting as an acceptable and efficient alternative to formal advertising.

Senator Lawton Chiles of Florida and the Commission of Government Procurement took up the cause and have been doing battle with the RAN/D&F ritual since. He introduced S.1264, "A Bill to provide policies, methods, and criteria for the acquisition of property and services by executive agencies," early in the first session of the 95th Congress—almost 4 years ago. This bill would have terminated the RAN/D&F ritual by specifically authorizing procurement for competitive negotiation in cases where the criteria for procurement by formal advertising are not satisfied. The 95th Congress passed into history without action. Now Senator Chiles has updated the bill to S.5. Hearings have been held in the Senate but none have been held in the House as of this writing.

"The System" and the Brain Drain

With so much technical time and talent burned up in the RAN/D&F ritual and other demands of the system, how much is left to do the hard technical work that has to be done to innovate new capabilities? While this issue has apparently escaped serious research, there are indications that the toll is much higher than generally realized.

In testimony to the Senate Armed Services Committee, Kelly Johnson, manager of Lockheed Aircraft's famous Skunk Works, addressed that topic. The following are excerpts from his testimony.

SENATOR SYMINGTON: That demand for justification, does that come from the branch offices of the service in California or wherever your plants are? Or does it come from Washington, or both?

MR. JOHNSON: Basically, it stems from the Pentagon, and they put their management systems into Wright Field and in the Navy offices. The thing I showed you here in the table about the progress reports required per month keeps hundreds and hundreds and in certain cases thousands of people generating paper which nobody reads.

MR. JOHNSON: It is not all that indirect. I have made constant surveys over the 20 years about what percentage of an engineering group actually is engaged in putting a line on paper, writing an analysis that has to do with the hardware. In 1956 I had an engineering department, California division, of 5,000 people. I found that 5.6 percent of the total time was spent in actually addressing the problem: How to make the hardware. I found out about 10 years later they were down to 3 percent. . . .[4]

In a humorous talk to an engineering management group, Dr. Robert A. Frosch, Administrator of NASA and former Assistant Secretary of the Navy (Research and Development), discussed the issue of how scientific and technical talent is consumed by the system. "A question . . . comes up regularly as I review programs, and it is one that all managers ought to contemplate," Dr. Frosch told his audience:

> . . . that poses some problems for me that I have never solved but am trying to tear into. I am presented with a project in which something is to be built. The output of the development is an object of finite size, 10 inches in diameter and five feet long with so many elements in it. I am told that work for the next year will consume $*N* million. So I pick whatever seems to be the going number for the cost of an engineer . . . with his engineering support and divide it into the $*N* million and I discover that this finite object, of which we are going to build 4 and test 3, is suddenly surrounded by 500 engineers. I ask myself, "How do they all get their hands on the object?" What is it that all of these engineers are doing? How much of it in fact is productive work that has to do with the design, construction, and testing of the object and how much of it has to do with something else that is not a proper part of the engineering job

4. Clarence L. "Kelly" Johnson, testimony before the Senate Committee on Armed Services hearings on the Weapon Systems Acquisition Process, 12 May 1972.

> but is somehow imposed by the Navy, or imposed by the Government, or imposed by our particular culture for doing engineering. From time to time I have been able to identify and demonstrate in a particular case that in fact about one-tenth of the engineers involved were in fact doing engineering in any traditional sense and the rest were writing each other memos.[5]

Attempts to Change the System

While nothing has been done to stem the massive talent hemorrhage of the RAN/D&F ritual, we do not say that nothing has been done. Substantial changes have been made, particularly in the process for acquisition of major systems, with emphasis on weapon systems. The thrust of most of these reforms has been an attempt to control cost overruns through strengthening of control by agency heads and the Congress.

In the 1960s, Congress and some of the departments and agencies within the executive branch came under increasing pressure from the public to contain the costs of major military and space systems. This criticism was particularly directed toward the Department of Defense (DOD). Robert McNamara, then Secretary of Defense, answered the critics by introducing a number of wide-ranging innovations into the government's system acquisition process. These innovations included the program evaluation and review technique (PERT), incentive contracting, the planning, programming, and budgeting system (PPBS), and several others;[6] all intended to give government program managers and contracting officers clearer visibility and tighter cost control over their projects.

This trend in introducing cost control measures certainly did not stop there. It continued throughout the 1960s with other concepts, such as total package procurement and life-cycle costing, all designed to peck away at the source of cost overruns on major programs.

Then, in 1969, there was a flurry of "top-down" initiatives. In May, David Packard's memorandum[7] established the Defense Systems Acquisition Review Council (DSARC). Later that year, in July, the President and the Secretary of Defense commissioned the Blue Ribbon Defense Panel to examine the area of defense acquisition and management. Not to be outdone, Congress jumped on the bandwagon and created, by public law, the Commission of Government Pro-

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5. Dr. Robert A. Frosch, "Bureaucratic Engineering," talk to the Washington, D.C., Chapter of the IEEE Engineering Management Group, Washington, D.C., 12 January 1972.

6. J. Ronald Fox, *Arming America: How the U.S. Buys Weapons*, (Cambridge, Mass.: Harvard University Press, 1974).

7. David Packard, "Establishment of Defense Systems Acquisition Council," 30 May 1969.

curement (COGP) to study and recommend methods for more economical, efficient and effective procurement.

These recommendations and reports by the Commissions were followed by others[8] that both mirrored the same concerns and reinforced the recommendations. Then, in 1976, the Office of Federal Procurement Policy (OFPP), under the jurisdiction of the Officer of Management and Budget (OMB), issued the A-109 Circular[9] that translated the COGP recommendations into government policy concerning the acquisition of major systems.

While these measures appear to have helped to control cost overruns, there are grounds for suspicion that the "side effects" may prove much more devastating than the "disease" they were designed to control. While schedule is continually referred to in the various documents, there is evidence that the acquisition process is lengthening.[10]

Selected acquisition reports (SARs) for major systems show the length of procurement cycles to be increasing. Major missile systems are now taking on the average of 61 percent longer to acquire than in 1971.[11] Aircraft, too, are taking longer to become operational and are "now [1976] reflecting about nine years to IOC compared with five and one-half years in 1971."[12]

We believe this case illustrates the general futility of attempting to reform the system through *ad hoc* "problem solving." In this case these actions have been of some utility in cutting cost overruns, but at the sacrifice of the combat edge which comes with achieving operational capability with new weapons while they still enjoy technical superiority over the weapons they must face in combat. The F6F Hellcat was a great weapon in early World War II but would have been a dubious asset if its development had been stretched out so that it was not combat-ready until Korea.

Who is responsible for the mess? We believe there are two answers to that question: "Nobody," and "Everybody." Bill McLean, father of the Sidewinder missile, was not the first to observe that "Success has a thousand fathers; failure is an orphan." However, McLean went on to explain why that is true for systems acquisition. McLean held that you could always identify a "creative designer"—

8. Two reports of significance: (a) Logistics Management Institute Report, *The Development of Requirements for Major Weapons Systems*, Washington, D.C., July 1973; (b) Alexander H. Flax, Chairman, *Report of the Acquisition Advisory Group*, Vols. 1 and 2, 30 September 1975.

9. Office of Management and Budget, Circular A-109, *Major System Acquisitions*, 5 April 1976.

10. Jacques S. Gansler, "A New Dimension in the Acquisition Process," *Defense Systems Management Review*, Autumn 1977.

11. James B. Lincoln, *Managing Total Acquisition Time: A New Priority for Major Weapon Systems*, Study Project Report PMC 77-1, Fort Belvoir, Va., May 1977, p. 7.

12. *Ibid.*

Bill McLean for his Sidewinder, Ed Hinnemann for the A-4, Kelly Johnson for the U-2, Michelangelo for the Sistine Chapel—for the successful programs, but seldom for the failures. He held that the reason you have difficulty identifying the "architect of failure" is that there was no creative designer controlling those programs. Rather, the systems were the vector-sum result of a lot of influences; they were "camels" designed by committees.[13]

On Controlling and Rationalizing the System

The real heart of our proposal for bringing the system under control is assignment of clear design responsibility for the acquisition system in its totality and for every identifiable subsystem of the overall system. We propose a "bottoms-up, inside-out" approach—turn the improvement job over to the people who are the system; apply the basic approach which underlies the profitability of Proctor and Gamble, the productivity of Texas Instruments, and the reliability of Maytag appliances.

This powerful but simple process involves the following six steps:

Step 1—Assign accountability for improvement. The first element of getting organized is to pin down responsibility (and accountability) for the performance of the acquisition systems and its subsystems. The basic rule is that the official responsible for day-to-day operations is also to be responsible (and accountable) for understanding and improving that part of the overall system through which his operational responsibility is accomplished.

In a "government of laws" it is not possible to delegate to each responsible manager full authority to alter the design of his system. However, each manager can be held accountable for these functions:

—Understanding his system;

—Identifying his "problems" or "innovation opportunities";

—Solving those problems which can be solved with the knowledge, resources, and authority available to him;

—Taking action to bring the most important of the remaining problems to the attention of officials with the authority necessary to effect the problem's solution.

These accountable managers will be supported by teams from their organizations. The overall improvement organization will consist of an interrelated structure of improvement teams and should be built from the bottom up. The basic building block of the organization will be teams consisting of first-level supervisors and a half-dozen or so of his/her subordinates who actually do the nitty-

13. William B. McLean, testimony before the Senate Committee on Armed Services hearings on the Weapons Systems Acquisition Process, 8 December 1971.

gritty work of the system, e.g., getting out a $9,000 purchase order. Higher-level teams will be staffed by the leaders of the lower-level teams up to the top-level team for the overall acquisition system. *Ad hoc* experts will serve with the teams when a team believes their particular knowledge and skills are required.

Step 2—Define improvement objectives. The first step is to hammer out some coherent picture of the capabilities we want the system to have after it has been brought under control. As in development of hardware, we should define these performance objectives quantitatively where possible.

Before we can put numbers on our aspirations, it is first necessary to define the yardsticks through which we will define what constitutes being better for the overall system in its totality, and later for its subsystems and lower-level system elements.

Here are three yardsticks we propose for use in setting performance objectives for the macro acquisition system after it has been brought under control:

—Assignment index—a measure of the percentage of our nation's total supply of people qualified by training and experience to contribute to technological innovation who are in jobs where they can do so.

Total Assigned to Doer Jobs
Total—Doers + Reviewers, etc.

—Application index—a measure of the percentage of the time of people in doer jobs available for actually doing the job—the time left after the demands of "the system" are satisfied.

Total Time Available for Doing
Total Time of People in Doer Jobs

—Time utilization index—a measure of the percentage of elapsed program calendar time actually devoted to innovating new capabilities. This is total elapsed time less time spent "marking time" waiting for funds to become available, waiting for RFPs to come out, etc.

Total Time Spent Doing
Total Elapsed Program Calendar Time

It is clear that we don't know enough at this time, in any rigorous sort of way, to establish usable quantitative objectives for the capabilities and costs of the system, nor for its subsystems either. However, under the approach we propose, such objectives would be established by the in-house improvement teams at some time during the improvement process.

Step 3—Document the "as is" system. The teams will document the "as is" processes which collectively constitute the system. This will be done in a highly disciplined manner through use of flow charts and other readily available aids. The output of this process will be an explicit "model" of each team's system as it

is, or was, before initiation of improvements.

It is interesting to speculate on just what a multiple activity chart of a typical system acquisition process would look like.

Assume that for the sake of simplicity the model was limited to the following parallel activities:

—Resource acquisition—including the planning, programming, and budgeting process within the bureau, department, OMB, two houses of Congress, and the presidency, and subsequent apportionment and allotment processes culminating in money available for obligation.

—Program approval—including all of the many milestone and other go/no-go decisions at all levels.

—Procurement—including all source selection and contracting activities.

—Hardware development—including all scientific and technical activity, after the Milestone 0 or program initiation decision, which is designed to contribute directly to the desired new capability.

—Non-hardware system development process—involving the training of people, development of support capability, etc.—all the non-hardware elements of the total system required to have an operational capability as differentiated from having only superb hardware of impressive "potential."

If we did a multiple activity chart model of a typical 20-year modern weapon system acquisition, how much of those 240 months would be all-out, moving-ahead, technical activity? What time utilization index would we find? Would it be as high as the 25 percent David Packard reported—2 years to get the planes in the system; 6 months outside the system? Do modern-day acquisition programs take so long because of the inherent technical difficulty of achieving the capability objectives of those programs, or is much of that time wasted by the internal operations of the system?

Step 4—Question each process as a whole and each individual step. The team first asks why the whole process has to be done at all. If the process is judged to be necessary, the team will question the requirement of each individual step: What is its purpose? Where should it be done? When should it be done? Who should do it? How should it be done? The output of this process should be a collection of all the best alternatives for improving the process.

This step is typically a group activity where all the people involved examine the model from Step 3 and thoroughly question (Why? What? Where? When? Who? How?) the existing process as the collective creative capabilities of the group are energized to devise a menu of improvement options.

Step 5—Define the proposed process. The team selects from among the best of the alternatives explored in Step 4 to define the proposed system.

Step 6—Sell and install the new process. Under the traditional approach to change, selling the proposal involves convincing the people who must make the system work that it is a good idea. However, under the bottoms-up approach, people who must make the new process work are the ones who developed the idea and are therefore committed to it. Thus, in the bottoms-up approach, selling involves clearing the proposal with teams for interfacing processes and getting the hierarchy's approval. The installation process is relatively straightforward since the people who must make it work are thoroughly knowledgeable about the new system and its supporting rationale.

Implementing the Program

Step 1 should be implemented immediately throughout the acquisition system. Orders should be issued to make every official accountable for both the efficient administration of his responsibility and for doing what he can to rationalize that part of the system through which he accomplishes his day-to-day responsibility. The subsequent steps should then be implemented in an orderly and step-by-step way. Limited-scale application can be undertaken, followed by larger-scale application based on the lessons learned in the initial tests.

This walk-before-you-run approach is most important. If a decision is made to go immediately into full-scale application without first building and testing some prototypes, the effort will probably fail. The truth of the matter is that not every organization can productively implement improvement through involvement without first making sure that some necessary prerequisites are satisfied.

Here are some of the conditions which will generally kill successful exploitation of improvement through involvement.

—*Win-lose adversary relationship between management and the work force.* For improvement through involvement to succeed, it is necessary to have a high degree of mutual respect and confidence on both sides. Both sides need to see themselves as respected members of a team working together to achieve the common purpose of efficient accomplishment of the mission.

—*Insecure managers who see suggested improvements as attacks on their competence.* Organizations which most effectively exploit improvement through involvement are blessed with managers who are psychologically secure. They realize that improvements are always possible and are not devastated when their subordinates develop means for accomplishing a function at 10 percent of the old cost, or show how to eliminate the job completely.

—*View of wages and salaries as just another cost to be minimized.* The unfortunate truth is that the typical government bureaucracy involved in the acquisition process is locked in a "war" in which management is trying to win by reduc-

ing the work force, and the organization is trying to survive through exercise of an array of "weapons" and "tactics" including "backlog management" and "systematic work complication." If the work force believes that their helping to improve productivity will cost them their jobs, there will be no significant improvement through involvement.

It is not necessary, nor even desirable, to promise that no jobs will be eliminated. It is necessary that workers believe that if they help eliminate their jobs that they will not thereby suffer loss of income. A number of conditions and actions can help to build this belief. For example, the initial implementation can take place in an organization with a rapidly growing workload where increases in productivity can be reflected in a reduction of the rate of growth of the work force.

The first demonstration should be conducted in an area where improvements will be relatively easy to quantify. We suggest conducting the initial demonstration in the contracting aspect of the acquisition process. This is an area which is practically made to order for the use of flow process analysis, an extremely powerful improvement tool. Costs and benefits are also easy to quantify. Some possible measures include:

—Time for the overall process from the intitial decision to initiate a procurement to the awarding of the contract, and time for completion of the various subprocesses, e.g., time from the procurement decision to the arrival of an approved procurement request and funds in a contracting organization; time from that event to promulgation of the request for proposal (RFP); time from promulgation of the RFP to award of the contract.

—Man-hours for each process in absolute terms and per procurement dollar involved. For example:

- -Man-hours of technical personnel required for each phase of the procurement process;
- -Man-hours of other government personnel, outside the contracting organization, required for each stage of the procurement process;
- -Procurement man-hours (man-hours of people assigned to the procurement organization);
- -Man-hours of vendors, broken down to show technical and support man-hours, required for proposal preparation and other aspects of the procurement process.

It is proposed that the test organization be selected from among volunteers. Prior to selection of the organizations to participate in the first round, sufficient briefings and other publicity must be presented so that procurement organizations satisfying the prerequisites discussed above are aware of the demonstration

and the opportunity to participate. One approach might be to select a test organization from organizations nominated by members of the work force, since the competence, psychological security, and attitude toward people is so critical to the success of improvement through involvement.

Summary and Conclusions

We have proposed bringing the system under control and rationalizing it by turning the job over to the people who *are* the system. Why should any reasonable student of the acquisition process believe this approach will succeed when most other attempts to improve the system have only made it more burdensome and ineffective? Past efforts have not been able to terminate the RAN/D&F ritual.

This bottom-up, inside-out approach will succeed where all others have failed. Here are some of the reasons why.

—*Closed-loop accountability.* The approach will pinpoint accountability for understanding and improving that part of the system through which managers accomplish their day-to-day operational responsibility. This coupling of two responsibilities, "bureaucrat as administrator" and "bureaucrat as engineer" will make possible enforceable accountability for both functions, and will frustrate the standard tactic typically used to defeat outside-in, top-down attempts to bring about change. This is the "bureaucrat–policy-maker game."

In this game the changee, the official whose domain is the object of the change efforts of the changor, the policy official or outside advisor attempting to bring about change, argues that the obvious inefficiency is due to regulations which he is obliged to follow. Since the changee knows far more about these regulations than the appointed officials for whom he nominally works, this tactic is very difficult to deal with.

However, when responsibility for both administering the system and understanding and improving the system are assigned to the same individual, the tactic just won't work. If the official claims the contracts take so long to get out because of stupid rules, evaluation immediately shifts to his efforts to identify needed improvements and either make them or bring them to the attention of the officials with the requisite authority or resources to make them.

—*Total system approach.* The proposed approach provides the means to tackle the system in its totality, at all levels. By assigning improvement responsibility to each manager (assisted by his own work team), the total system is covered "top-to-bottom" and "wall-to-wall." Problems will be identified and solved at the lowest level where the requisite authority exists.

One of the reasons for the durability of the "let's reorganize" ritual—a ritual

probably more costly and counterproductive than the RAD/D&F ritual discussed earlier—is that top officials, lacking the power to come to grips with the real problems, do about the only thing they can do—shuffle the boxes.

Under the approach we propose, most of the beneficial effects, such as reducing time (too often 6 months to 2 years) required to get out a contract, will be the result of the cumulative impact of very minor improvements by the work teams improving the details of the process. The minutes and pennies add up to years and millions.

With improvement opportunities identified and exploited at the lowest possible level, top-level people will have the time and energy to deal with the system in its totality and really come to grips with the problems which can only be dealt with on a total system basis.

—*Track record*. What we are proposing is not new and untried. The approach is basically Frederick W. Taylor's scientific management as modified by Lillian Gilbreth, Allan Mogensen, and others who recognized that the people who know most about a job, and are therefore best qualified to improve it, are the people doing the job. Here are some results of the approach in action.

—Texas Instruments, with its total participation in its people and assets effectiveness program, has increased productivity by 15 percent per year while simultaneously reducing the costs of its products.

—Procter and Gamble, through its deliberate methods change, has cut its costs by over $300 million per year and achieved a pre-tax profit on sales dollar of 10 percent.

—During the mid-1970s, an in-house team from the Bureau of Drugs of the FDA overhauled the paperwork support associated with the process for approving new drugs. Working part time (except for one member), the team completed the job in about 6 months. Results included a 59 percent drop in delinquent reviews, a doubling of reviews per reviewer, $.75 million one-time savings and $.25 million per year ongoing savings. Total consultant time (for training the in-house team) was 15 days.

—In the early 1960s, VA 126, a squadron flying F9F Cougars at NAS Miramar in San Diego, reduced the time its planes were in scheduled periodic maintenance from 10 days and 275 man-hours to 1 day and 100 man-hours with a reduction in test flight deficiencies of over 80 percent. The squadron went on to run up successive annual all-Navy safe flight hour records.

—In the early 1960s, a small in-house Navy team developed, documented, and applied the integrated logistic support (ILS) concept that is now used throughout the Department of Defense.

—*Approach to change*. One of the major reasons improvement through involvement has been so effective is that it outflanks resistance to change. Under the approach we have described, change is proposed by the people who must make it work. People don't resist change; they resist *being* changed.

Raw Material Supplies and Related Subjects

28

Maureen P. Sullivan

Many discussions on raw materials focus on the question: "Is there enough?" Articles and books, and investigating committees and commissions, ask the question: "Does the world have an *abundance* of mineral resources?"

The consensus is that, yes, there are enough raw materials to meet the current demands of industrialized, and developing nations. There is enough iron, nickel, and chromite for the next 100 years.[1] These estimates do not include reserves yet to be discovered; deep-sea mining potential; or break-throughs in technology that allow for the economic utilization of low-grade or seabed ores. Nor do these estimates account for substitution of materials. There should be even more raw materials as conservation programs become common.

The problem of enough resources is no longer a dominant one; rather, the issue is the equitable distribution of resources, and a guaranteed source of supply without interruptions. Irregular supply conditions, strained relations among trading partners, economic warfare, spot shortages, and rapid price fluctuations have been the subjects of recent discussions.

Resource availability has been a particularly important subject because an assured materials supply is essential for the smooth operation of a highly industrialized economy such as that of the United States. Indeed, it is important to most economies. Because many production methods are basically capital intensive and require long lead times, advance planning is necessary to assure the availability of resources. To protect against interruptions in the supply of materials (and rapid price fluctuations), material inventories must be maintained. The more undependable is the supply of a particular material, the larger, and hence costlier, is the inventory. Suggestions to guarantee adequate resource supplies for efficient and economical production of goods have included: stockpiling; price controls (effective only for those materials in which a nation is self-sufficient); export restrictions; trade agreements; favorable policies towards private firms, i.e., multinational corporations, rationing and allocation plans; and development of alternative sources of supply.[2]

Although the thrust of most raw materials discussions has centered on the

1. AFL-CIO, *Raw Materials For America*, 1975, p. 23.
2. Congressional Budget Office, *U.S. Raw Materials Policy: Problems and Possible Solutions*, 28 December 1976, p. x.

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availability and abundance of raw materials, little attention has been paid to a third and increasingly important issue—whether or not the United States has the *capacity* for refining, processing, and casting semi-finished products from the materials available. This has not been of general concern until recently and very little material is readily available on the subject.

In this discussion, I will analyze and review the raw materials question from the three aspects of abundance, availability, and capacity.

Abundance vs. Availability

There has been debate the last two decades whether or not there are adequate supplies of raw materials in view of sustained world exponential economic growth, and finite non-renewable resources.

The Club of Rome's 1972 report, *The Limits to Growth*, typifies one side of the debate. The report has warned that the "earth's interlocking resources—the global systems of nature in which we live—probably cannot support present rates of economic and population growth" for many more years, even with advanced technology. Furthermore, the report has projected that given the world growth rate in terms of population, industrialization, and resource usage, all of the world's non-renewable materials will be depleted within 50 years unless drastic conservation measures are established. The other side of the debate has severely criticized this prognosis of the imminent exhaustion of resources. As expressed by economist Lester Brown, "the U.S. and the world are moving from an age of relative resource abundance to an era of relative resource scarcity,"[3] but not to an era of resource depletion (see Table I).

A reevaluation of the world's resources, the discovery of new reserves, and a slowdown in the growth of the world gross domestic product and world population confirm that for most of the industrially strategic raw materials (iron, alumina or bauxite, copper, tin, lead, zinc, manganese, chromium, and nickel), the earth's resources are sufficient to meet anticipated demands well into the next century.

Before World War II, the United States was relatively unconcerned about raw material shortages. It was self-sufficient in energy, copper, and iron, the prerequisites for an industrialized economy, as well as in other non-ferrous minerals. However, concerned government personnel, industrialists, and economists recognized that World War I had not only disrupted the price structure of most of the materials, but had also drained many of the reserves of high-grade, accessible

3. Alfred E. Eckes, Jr., *The United States and the Global Struggle for Minerals*, (Austin: University of Texas Press), 1979, p. viii.

TABLE I

Comparison of the ratio of reserves to production (R/P) in 1934 with the same ratio and the ratio of reserves to primary consumption (R/Cp) in 1974 for five major earth resources. Figures are for the United States. Figures for copper, iron ore, lead, and zinc are in thousands of metric tons; for crude oil, in millions of barrels.

Resource	1934 R/P approximate	1974 Domestic mine (well) production	1974 Net imports (primary and secondary)	1974 Domestic secondary supply	1974 Domestic reserves (R)	1974 R/P	1974 Domestic primary consumption (CP)	1974 R/Cp
Copper	40	1,441	391	455	81,800	57	1,640	50
Iron ore	18	83,000	46,000	NA*	2,000,000	24	140,500	14
Lead	15-20	615	82	564	53,600	87	800	67
Zinc	15-20	447	655	77	27,300	61	1,150	24
Crude oil	15-20	3,043	1,268	NA*	34,250	11.2	4,447	7.7

*NA not applicable.

SOURCE: *Science,* 20 February 1976, p. 679.

ores. To preserve the U.S. independence from foreign supplies, some efforts were taken to establish conservation measures, regulate exports of raw materials, and define terms of access.

It was not until during and after World War II that attention focused on raw materials supplies. Although the United States was still basically self-sufficient in most materials in 1945, the war had rapidly depleted many domestic high-grade ore reserves to meet America's war efforts, as well as those of its beleaguered allies.

"During the five years (1941-45) of mobilization and combat, domestic mines and wells produced in excess of 3 billion tons of coal, a billion tons of petroleum, 500 million tons of iron ore, 2¼ million tons of lead, 3½ million tons of zinc, 5 million tons of copper, and 14 million tons of bauxite."[4] The quantity of minerals produced in 1943 alone was 57 percent more than the 1918 output, and 23 percent above the boom year 1929.[5] By the end of the war, reserves for petroleum, zinc, copper, and lead had been depleted by 60-80 percent. During the war, little

4. *Ibid.*, p. 121.
5. *Ibid.*

forethought was given to (1) the effect of depleted ore reserves on post-war industrial efforts, and (2) how rapid rates of production of high-grade ores would affect post-war patterns of mineral consumption.

To supplement the domestic supply base to meet military and civilian needs, and to augment the list of rare materials required by new military technology, the United States began to import heavily from South America and Africa. Except for coal, iron, and salt, every mineral for the war effort had to be imported in some quantity.[6]

This growing dependency on imports during World War II foreshadowed a shift in post-war United States supply patterns and material requirements. This important dependency meant that the United States could become vulnerable to the vagaries of international markets in terms of price and supply. Most important, in future conflicts the United States could lose access to its vital overseas supplies, including American-owned mines.

In deference to government officials and industrialists, who were concerned with the prospect of resource dependency in an interdependent world, the U.S. Government in 1939 authorized a stockpiling effort to commence; however, during the war, the mobilization of materials was given preference to the stockpiling effort. By 1943, attention again turned to establishing post-war stockpiles of strategic materials. Conflict arose as a result of partisan industrial and congressional disagreements over which materials would be stockpiled, and how they would be disbursed. An agreement finally was reached in 1946 on a national stockpiling policy and specified which materials would be classified as critical, the rate of accumulation, and the amounts to be stockpiled.

The acceleration of the depletion of natural resources during World War II gave the government impetus to seriously consider its overall national materials policy. Events in the 1950s gave further emphasis to this situation. The Soviets threatened world domination, or at least control of those areas supplying vital raw materials.[7] This was seen as endangering the efficient allocation of global resources. Without guaranteed access to materials, the United States and its allies would not be able to maintain an open-world economy to sustain their post-war economic recoveries. Urgent consideration had to be given to the prospects of long-term materials supply.

6. *Ibid.*, p. 122.

7. This Soviet threat is relevant today. It is evident from numerous articles on Soviet policy that one of its main aspirations is to use materials as a pawn in the struggle for world power. Since one of the weaknesses of the United States is its dependence on imported minerals, then disruptions or stoppages in the supply of these minerals is an obvious goal of Soviet strategy. For further discussion on the Soviet view of economic warfare see *The Sea Power of the State* by S. G. Gorshkov. For an example of Soviet manipulation of the metals market, see the article from *Business Week*, May 1979.

During the Truman and Eisenhower administrations, several commissions were established to study the raw materials situation. These commissions agreed that the country was facing an inevitable exhaustion of domestic resources; that it must institute measures to protect itself from materials shortages and price increases; and that it was increasingly susceptible to foreign interference. However, the presidential commissions could not agree on when the United States would run out of materials; moreover, they could not agree on whether U.S. policies should be based on international cooperation (i.e., resource management agreements, trade agreements, development of resources in undeveloped countries), or should be domestically oriented. If domestically oriented, policy emphasis should be placed on developing domestic areas of low-grade ores, on advances in technology to utilize low-grade ores, materials substitution, and conservation. What finally emerged was a national materials policy, vaguely defined, which tried to satisfy all parties.

By the 1960s, concern over the future availability of raw materials had diminished. Neither the exhaustion of resources, nor the implication of rising raw material costs was an issue. This was due to several factors.

Until 1964, the U.S. balance of trade remained positive (in spite of increasing dependence upon large quantities of imported metals), due primarily to available materials from American-owned mines abroad. Also, the raw materials market was experiencing a period of overexpansion and under consumption, due to "predictions of shortages and ambitious government-subsidized metals development programs."[8] Substitutes like plastics and fiberglass had come on the market. Because of advanced technology, using lower-grade ores was economical. There was little apprehension concerning further depletion of raw materials.

The only foreseeable threat was competition with the Soviet Union for foreign materials sources. Little thought was given to increased competition from allies such as Japan or West Germany. The United States felt confident that except for short-term dislocations, long-term scarcity of materials was no longer the vital issue it had been in the late 1940s and 1950s.

This complacent attitude remained until the unexpected 1972-74 commodity crunch when there were severe shortages of raw materials, followed by rapidly rising commodity prices. This was the result of three basic events: "(1) a slowdown in the rate of expansion of industrial capacity beginning in the later 1960s; (2) a sharp surge in demand beginning in 1972, that occurred almost simultaneously in all major industrial countries (as well as developing countries); and (3) a 'shortage mentality' (manifested by such phenomena as double-ordering

8. Eckes, p. 230.

by purchasing agents) that was caused by, and which in turn compounded, the demand and capacity problems discussed above."[9]

In other words, on the demand side, competition had been increasing for materials as the United States, Great Britain, Western Europe, and Japan increased their industrial output. Simultaneously, developing nations required more raw materials for the development of their infrastructures.

On the supply side, lagging profits in the metals industry, and a large variety of domestic and foreign events slowed the expansion of new capacity, and impeded capital investments. Lead times to bring new mines into operation grew due to new environmental and safety regulations. The United States began to sell minerals from its stockpiles and created uncertainty in the markets, which was reflected in price fluctuations.

These trends culminated in 1973-74. The Arab oil embargo, which escalated oil prices, was part of a larger pattern. Other mineral prices rose rapidly, due partially to shortages. For example, "zinc and tin prices more than doubled, and copper (prices) increased by 50 percent."[10]

The United States realized it had no materials policy relevant to the raw materials situation after 1973-74. The General Accounting Office said that the government's response to materials problems was "at best *ad hoc* and crisis oriented." The U.S. Government lacked (and still lacks) an adequate planning, policy analysis, and a policy formulation *system* for basic materials issues. "This lack of a system has hampered the government's ability to deal with short-term problems and to anticipate the impact of foreseeable long-term trends.[11]

The Capacity Problem

Since 1974, government and private agencies have been attempting to establish a workable and flexible raw materials policy for the United States. It has been estimated that if no concerted effort is made, the non-energy materials gap will rise from $9.5 billion in 1974, to $40 billion by 2000.[12] "While domestic resources or substitutes might alter the composition of imports, shortfalls of aluminum, iron ore, and copper (appear) likely to account for much of this deficit."[13] This materials shortage has potential economic and defense ramifications. To offset this potential materials gap, policy-oriented specialists have been

9. General Accounting Office, *Learning to Look Ahead: The Need for a National Materials Policy and Planning Process*, 19 April 1979, p. 7.
10. Eckes, p. 249.
11. General Accounting Office.
12. Eckes.
13. *Ibid.*

pursuing the old but still valid policies of stockpiling, bilateral and multilateral commodity agreements, and technology advances in materials substitution.

However, little attention had been given to a problem that is beginning to equal the problem of availability of resources. A growing trend indicates that the industrial base needed to supply the builders of automobiles, ships, airplanes, etc., with semi-finished products such as steel, aluminum, and copper materials castings and shapes is becoming smaller. Many of the basic industries are either closing plants, cutting back on production, moving operations overseas, or importing the processed materials due to high energy prices; the cost of meeting EPA and OSHA regulations; the difficulty in raising capital for the expansion; modernization or building of new plants; the rising cost of labor; and the difficulty in obtaining relatively inexpensive raw materials.

The decline in the number of forging, casting, and processing industries in the United States poses a serious problem to the production output of domestic metal-working and engineering industries, which depend heavily upon those primary industries. The defense companies would be hit hardest. Of the 100 top defense contractors in 1978, almost one-half were metal-working related firms. Over the past 10 years, of the 33 companies that were among the top 20 at one time or another, 28 were metal-working related.[14] Dislocations in the supply of processed materials needed to build weapon systems would severly affect the production output of the defense companies involved.

It is important to clarify the industries concerned: basically those which refine and process raw materials into the primary materials (ingots) such as iron, steel, aluminum, and purified copper; milling operations which shape the primary materials into rods, strips, or sheets; and, finally, the foundry industry which produces the metal castings required as end products or component parts. Castings are produced by pouring liquid iron, steel, aluminum, brass, or other metals into cavities of sand, metal, or ceramic molds designed to produce the desired shapes.[15] (Table II depicts how the industries fit into a production process.)

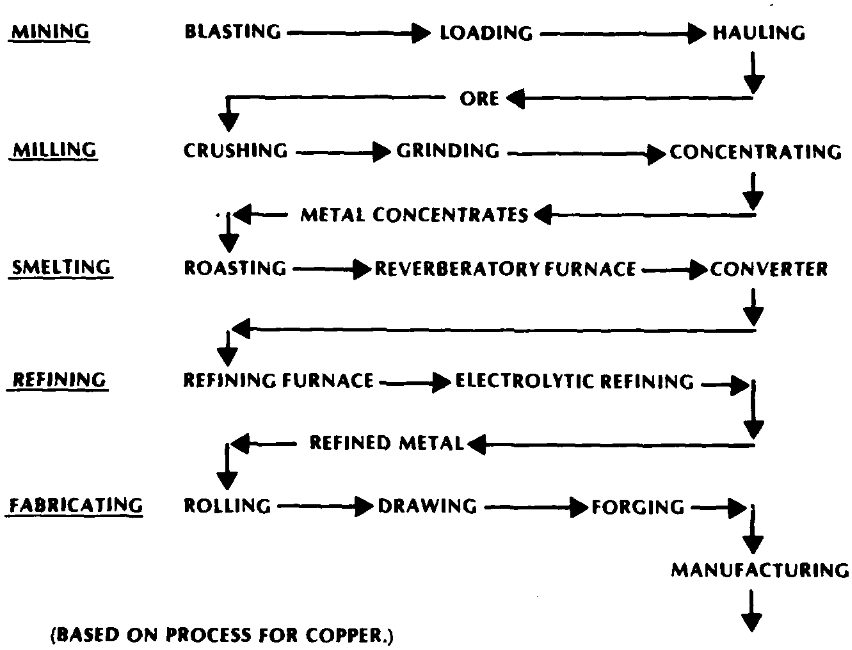
Of the three industry groups mentioned, foundries are perhaps the most important.[16] An article in the *National Defense Magazine* in March-April 1976 said that the foundry industry is the Achilles' heel of the entire defense-industrial base.

14. *Iron Age*, "Defense Contract Seekers Eye Future Fiscal Plans," 9 July 1979, p. 32.

15. *National Defense*, "The Foundry Industry—Achilles' Heel of Defense?" March-April 1976, p. 366.

16. There are over 4,400 foundries in the United States that produce over 18 million tons of castings per year at a value of over $20 billion. These foundries employ over 400,000 workers. On a company-to-company basis, foundries are small businesses. Only 7½ percent of the foundries employ fewer than 100 people. Yet on a value-added basis, the metals casting industry is the nation's fifth largest industry. *Ironcaster*, "Cast Metals Foundations," April 1979, p. 13.

TABLE II
BASIC STEPS: Metal ore, Finished product



(BASED ON PROCESS FOR COPPER.)

The metal castings produced by the foundries are needed for the production of 90 percent of all durable goods in the United States. "Without foundries, there would be no ships, helicopters, aircraft, guns, tanks, motor vehicles or hundreds of other metal products."[17]

The foundry industry has been declining steadily in the number of its plants since 1950—a decline in gray- and ductile-iron foundries (the principal types of foundries) from 3,000 to 1,375 between 1950 and 1975. At the same time, demand for all castings is increasing at a rate of 6 to 7 percent annually.[18] The primary reason for the decrease has been that metal casters "have not traditionally generated the funds to modernize, expand, and equip."[19] Lack of capital for

17. *National Defense.*
18. *Ibid.*
19. *Ibid.*, p. 368.

reinvestment, and the huge capital expenditures required to comply with clean-air and OSHA standards have forced many foundries to close. Those that have not closed had to raise the prices of castings. These factors have caused many large end-user companies to turn to foreign foundries, and to import lower-priced castings.

A review of articles on steel, aluminum, copper, and other processors of metals shows that domestic production is falling behind demand in almost all industries except steel. Very little of this claim is quantifiable because the trend is only now being realized. Much of the decline in production has been attributed to the recession of 1974-75, and to the current recession. However, a more serious cause in the decline in output has been that smelting and refining capacity for lead, copper, zinc, aluminum, etc., is being slowly strangled by environmental regulations, and rising energy costs. As a result, a number of plants are closing and/or moving overseas.

A case in point is a story that appeared recently in the *Washington Post*. The aluminum industry, which is highly energy-intensive (see Table III), is moving many of its plants overseas where energy is less costly. For example, Kaiser Aluminum recently announced that it is building one of the largest bauxite/alumina refining plants (hydro-electrically powered) in South America, rather than in the Pacific Northwest as was planned originally. The reasons are the high cost of energy, a projected drain on the region's energy resources, lack of available water sources needed in processing bauxite, and strict and expensive environmental regulations.

To meet the demand for processed metals, many producers of copper, lead, and zinc are engaging processors in Japan and Germany to smelt and refine metals. They claim that efforts to pare production costs have been frustrated by the need to meet regulations that "cost money and time and talent with no resulting profit at all."[20]

According to industry estimates, the copper industry would have to spend $3 billion by 1985 to meet existing environmental, health and safety regulations. Such a diversion of funds from investment in productive facilities would result in a 17 percent decline in the domestic output of refined copper. Kennecott, for example, "spent $280 million to meet EPA regulations at its Utah Copper Division smelter only to be told by EPA that it may (soon) have to meet standards nearly twice as strict."[21]

Lead producers are worried that they do not have the technology or the

20. *Business Week*, "Now the Squeeze on Metals," 2 July 1979, p. 48.
21. *Ibid.*

TABLE III
Energy requirements for the production of abundant metals and copper. Gross energy is estimated at 40 percent thermal efficiency for generation of electricity. The last column gives the ratio of the energy required to extract a ton of metal for low-grade compared to high-grade ores.

METAL	SOURCE	GROSS ENERGY (Kilowatt-hours per ton of metal)	E_L/E_H
Magnesium ingot	Seawater	100,000	1
Aluminum ingot	Bauxite	56,000	1
	Clay	72,600	1.28
Raw steel	Magnetic taconites	10,100	1
	Iron laterites	11,900	1.17(with carbon) 2(with electrolytic hydrogen)
Titanium ingot	Rutile	138,900	1
	Ilmenite	164,700	1.18
	Titanium-rich soils	227,000	1.63
Refined copper	Porphyry ore 1 Percent Cu	14,000	1
	Prophyry ore 0.3 Percent Cu	27,300	1.95

SOURCE: *Science*, 20 February 1976, p. 686.

money to meet new exposure standards set by OSHA. "Secondary lead producers are now (in 1979) shipping 150,000 tons a year of scrap overseas to be processed, a tripling of 1975 export levels."[22] Although lead prices have climbed 87 percent during the last year because of tight supply on the world markets, industry

22. *Ibid.*

officials predict that the secondary lead industry will almost completely disappear in the United States as a result of not having the means to comply with OSHA regulations.

Zinc producers have closed down 9 out of 14 smelters in the last decade. A massive new plant that could supply 12 percent of U.S. needs (using advanced environmental technology) was brought on stream earlier this year by Gulf and Western Industries Inc.'s Natural Resources Group. Experts predict that the plant facility could be the last major smelter of any kind to be built in the United States.[23]

The last case in point is the steel industry. It, too, perceives long-term problems, although the demand for steel is booming. Many experts believe that today's profit surge is only a temporary reprieve. Major reasons for pessimism in the steel industry are the cheap imports from Japan and Germany, monumental pollution control costs, and the prospect of weak growth in demand as steel users such as automakers turn to lighter-weight materials.

These examples demonstrate that although the raw materials may be available, the United States may not have the capacity to convert them into the end products. There have been few documented studies or articles that address this problem. Nor is there a cohesive industry overview that analyzes the situation and how it may impact on weapons production, military preparedness, or on the U.S. economy as a whole. The ominous result of this problem of existing capacity is that the United States may become dependent upon foreign metal processors for goods, just as it has become dependent upon foreign suppliers for raw materials.

Conclusions

This discussion indicates that the United States' industrial might is dependent primarily upon two things: availability and access to raw materials, and the capacity to process these raw materials into semi-finished forms for the manufacturing of finished goods. We see that the United States, once self-sufficient and able to supply its needs for raw materials, has become dependent upon imports for many raw materials and, more recently, some processed minerals and metal goods. If this trend continues, the result could be a drastic undermining of the U.S. strategic position.

There is no indication that U.S. industry will go bottom-up. However, the security of supply remains a problem. Physical interruptions, shipping strikes, wars, price fluctuations, and local economic problems may abound. As the

23. *Ibid.*, p. 49.

United States becomes more dependent on imports, perhaps its ability to negotiate effectively for favorable deals will deteriorate because foreign nations will know they have the advantage.

Fears of embargoes by foreign producers may be unfounded because it would not be to their economic advantage. However, price manipulations are a real hazard. The United States no longer has the leverage of being the dominant buyer of all metals and metal products; there now is increasing competition from Europe, Japan, and the Soviet Union.

To resolve the potential threat to U.S. industrial activity, we need a concerted effort on the part of government and industry to examine the inherent problems of supply, and to establish policies that will increase U.S. self-sufficiency. ||

The more than 1,800 students that pass through the Defense Systems Management College each year are able to increase their knowledge of defense acquisition and enhance their managerial skills by taking advantage of the many educational resources of the College. But DSMC is unique in that the students themselves represent a valuable educational resource. They bring to the College an enormous depth and breadth of acquisition experience that both supplements and is supplemented by the DSMC educational program.

The nine short articles that follow were prepared by students of Program Management Course Class 80-1 in response to a requirement of the Program Funds Management subcourse under the direction of Dr. Fred Waelchli, Mr. Robert F. Gardner, and Commander Allen L. Cahill, USN. The papers reflect the broad scope of the students' interests and experiences, and demonstrate their ability to come to grips with some of the more perplexing issues in materiel acquisition and in program funds management.

Program Manager Control Over Expenditures

42

Major Lewis W. Long, USAF

A major challenge facing program managers during every phase of the systems acquisition process is to effectively obtain and manage program funds. The importance of adequately justifying time-phased funding levels through the DOD planning, programming, and budgeting system is evident to even the most inexperienced program manager. Likewise, most program managers are acutely aware of their personal responsibility to assure the timely commitment and obligation of funds allotted to their programs. Unfortunately, too few program managers devote sufficient attention to the final step in the budget execution process; the management of funds expenditures. This responsibility for expenditure control is a relatively recent development that has come about in response to congressional pressure. It is also one in which the PM is under increasing pressure to fully assume. Unfortunately, the program manager all-to-frequently "abdicates" this function to his chief of program control business management or, even worse, to elements external to the program office. Among the many reasons that may be cited for this approach, foremost are a lack of appreciation of the potential programmatic implications of poor expenditure control, and/or a lack of awareness of available techniques to correct adverse expenditure trends. The purpose of this paper is to provide some basic insights into these issues.

From the DOD program management perspective, an expenditure is defined as an actual payment made against a contract or other obligation (e.g., MIPR or Project Order) to a contractor or another government agency/activity. Included are advance payments, partial payments, progress payments, and periodic payments against cost-type contracts. Obligated funds for which payment has not been made are referred to as unliquidated obligations (ULO).

While the obligation of funds is a recognized program office function, responsibility for expending funds against these obligations is normally vested in an activity external to the program office. In most instances involving contracts, this activity will be an element of the contract administration organization (DCAS or AFPRO) that has been delegated responsibility for administration of the contract. In the case of intra-governmental transactions, the paying office will normally be a disbursing or finance office of the procuring service. The basis for payment of an invoice is the matching of an obligation record, such as a contract, against a Contract Administration Office (CAO) certification that payment is justified and due. The significance of this is that most expenditures are made without specific

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prior recourse to the program office.

While not physically involved in the actual expenditure of program funds, the program manager is nevertheless charged with management responsibility for expenditure rate control. In this regard, a key tool of the program manager is that program's financial plan, which sets forth time-phased expenditure profiles. Simply put, these profiles represent the best estimate of expenditure rates *vis-a-vis* planned program performance. Of course, because of the many uncertainities inherent in systems acquisition/development programs, both positive and negative variances from these profiles frequently occur.

Often, but not always, higher than planned expenditures are indicative of substandard technical or managerial performance which, if unresolved, will result in increased funds requirements for the same work. Among other factors which may cause accelerated expenditures are unanticipated increases in overhead rates, abnormally high materials costs, and accelerated work progress. On the other hand, an expenditure rate that lags behind the planned rate can be indicative of either excellent cost performance or a lack of performance. It could also be associated with failure to record or report expenditures on a timely basis or failure to complete certain administrative actions on which payment is dependent. For example, incomplete final overhead negotiations, incomplete incentive fee negotiations, protracted audits and other similar situations can act to artificially depress expenditure rates. Regardless of the reason for the lag in expenditures, a high ULO balance can have significant repercussions on the program. Among these are the possible loss of program funds to other programs through higher-echelon reprogramming actions, a possible reduction in out-year funding levels because of failure to expend currently available funds, and the opportunity cost of not being able to use available, and perhaps excess, funds for other urgent program needs.

Summary Expenditure Date

Although not privy to real-time information on expenditures, the program manager does receive summary expenditure data on a periodic basis from two independent sources. First, the program office's servicing comptroller organization typically provides monthly summaries of program expenditures by both appropriation and fiscal year. Second, most systems acquisition contracts require the contractor to submit quarterly contract funds status reports which summarize expenditures to date as well as projected future expenditures. These two reports, when used in conjunction with the financial plan and other available cost/performance reports, enable the program office to identify variances that may affect the program.

Depending on the magnitude/significance of the variance, its causes, and other pertinent factors, there are a number of ways in which the program manager can influence expenditure rates. On one hand, he can take unilateral action within the program office to: (1) add or delete elements of work, (2) accelerate or defer elements of work, or (3) accelerate or defer the schedule of deliverable items. In addition to these direct actions, he can also indirectly influence expenditure rates through coordinated actions with the contractor, the CAO, and the disbursing office. Examples of possible actions include voluntary reductions in contractor overhead expenses, accelerated or lengthened negotiations/approvals, disapproval of requests for overtime work, or more timely processing and recording of expenditures by the disbursing office. To achieve maximum benefit from increasingly scarce program dollars, all members of the program office must understand the implications of expenditure control. In this regard, it is essential that the program manager clearly establish his interest in this process by becoming personally involved in the management of expenditures. In this way, he can assure that all members of the program management team strive to minimize variances from planned expenditure profiles. Moreover, the program manager must take positive steps to initiate various contingency plans which will permit him to react to short-notice expenditure problems. Such plans are not a luxury in the dynamic DOD fiscal environment; they are critical to the program manager who does not wish to risk the unnecessary loss of critically needed funds. ||

45 Budgeting for Innovation Early in the Acquisition Process

Lieutenant Colonel D. Brent Pope, USAF

OMB Circular A-109 provides explicit guidance designed to foster competition and to require exploration of a variety of alternative system concepts early in the development process for a major system acquisition.

> . . . Federal agencies, when acquiring major systems, will:
> a. Express needs and program objectives in mission terms and not equipment terms to encourage innovation and competition in creating, exploring, and developing alternative system design concepts.
> b. Place emphasis on the initial activities of the system acquisition process to allow competitive exploration of alternative system design concepts in response to mission needs.[1]

Many attributes of this approach are laudable and should provide the environment essential for continuation of the technological level of defense industry in the United States *vis-a-vis* the Soviet Union. With a strong, highly competitive aerospace/defense industrial base and many ancillary interests (e.g., educational institutions, commercial research centers), the prospects for new ideas to resolve critical requirements in the sophisticated warfare environment of the future appear to be endless. What A-109 does not address, however, are the specifics regarding the manner in which resources for such efforts are to be derived and managed.

In the pre–A-109 period, a program was essentially funded based upon a particular system approach prior to Milestone I. With a single system concept somewhat well-defined, it was a relatively simple task to identify and support funding requirements and a line in the budget request to the Congress. Under A-109, mission needs are identified in general terms, and industry, government, commercial laboratories, educational institutions, and the like are solicited to provide alternative ideas to meet those needs. The "system," if there is to be one, is not identified until Milestone I at the earliest, and may not be defined until Milestone II. The competitive prototyping phase leading to Milestone II could involve radically different system alternatives. In sum, on the front of the acquisition process, we no longer have a specific system definition to identify and sup-

1. Harold Brown, *DOD Annual Report Fiscal Year 1981*, Report of the Secretary of Defense to the Congress on the FY 1981 Budget, FY 1982 Authorization Request and the FY 1981-1985 Defense Programs, 29 January 1980.

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port a budget line. Indeed, any mission-area analysis or mission need may require a combination of system concepts. In addition, A-109 encourages a number of short-term iterative contracts "to explore alternatives and reduce risk." Such contracts might include subsystem hardware, or even system prototyping of different competitive system concepts, to demonstrate the resolution of critical issues. In its true sense, then, A-109 requires additional concentrated effort on the front end of the acquisition process to meet specific needs.

There are three primary budgetary consequences of this intensified effort early in the development. First, the amount of effort required has been substantially increased. Funding for a number of competitive iterative contracts, as opposed to the prior one or two, will require additional front-end funding. Second, and perhaps most critical, is the difficulty in communicating funding needs through the budgetary levels of the government. Prior to A-109, a line was established as system-specific. Under A-109, at the various review levels, a funding line to, for example, "evaluate alternatives for a potential close-combat anti-armor weapons system" quickly becomes the first area to be cut. Finally, the process required to examine a number of alternatives becomes iterative and complex, resulting in a stretched program on the front end. Not only will this increased schedule require additional funds, but at each annual review during this process the program must face the question, "If you don't know what you want, why don't you wait until you do know to ask for funds?" The Navy SIRCS and the Army AHAMS were the first two tests for A-109 in those services. It should be a signal to OMB and OSD that both programs met with severe opposition in discussion with intermediate reviews and the congressional staff.

How, then, can we establish funding for innovative efforts early in development in the spirit of A-109? The easy answer seems to be to apply the existing exploratory development funds (6.2) to this area. After all, these resources are provided to the services to explore new technology. The exploratory development funds could be used in some instances for the very early part of the acquisition process, or just after Milestone 0 when the progam effort is directed primarily toward paper studies. There are, however, a number of problems with continued reliance on existing exploratory development funds under A-109. As mentioned above, the level of funding in the early phase would need to be increased to allow for the evaluation of a number of alternatives and a more extensive front-end schedule. From my experience with the Army's AHAMS effort, I would estimate a funding increase of 20–40 percent above that required for past activities (dependent upon the range of alternatives and technology) leading to Milestone I and II decisions.

A more fundamental problem with current exploratory development funds is

the way they are administered. For example, in the Army, those funds are broken down to the various commands and laboratories under DARCOM. Each command or laboratory is established with its own area of expertise. Thus, if funds are provided to the Missile Command (MICOM) and the requirement is established for a new anti-armor weapon, for example, the alternatives at MICOM are only missiles. The Armament Research and Development Command (ARADCOM) would have only gun or recoilless-rifle solutions. In essence, the range of alternatives under A-109 is considerably narrowed once the funds are released to the separate commands or laboratories. Any solicitation issued from, for example, MICOM is interpreted by industry as requiring a missile solution. Even with extreme care and language to ensure "openness to new ideas" in drafting the request for proposal, the industry representatives know the source selection team from a particular command will be strongly influenced by the experience of the environment.

There are a number of possible actions OSD and the services could explore to improve this situation. One suggestion is to establish a pool of funds to support mission element needs as the needs statements (MENS) are approved. I suggest that OSD first determine the various mission-area categories. The next step would be to determine which mission areas are service-specific (e.g., submarine warfare), and which are defense-wide (e.g., strategic communications). Then OSD would assign the appropriate mission areas to each respective service and hold those defense-wide areas for decision control at the Secretary of Defense level. To reduce the problem of parochialism, the services should maintain control of new starts in their mission areas at the service headquarters or intermediate levels (e.g., DARCOM and TRADOC in the Army). The evaluation of candidate concepts would be conducted under the service or intermediate headquarters to reduce the influence of subordinate command bias in selecting alternatives for further development. For the period leading to an early milestone decision, the program manager would report to the intermediate or service headquarters. Once a particular system approach is selected, the program would come under the control of the appropriate subordinate command.

A portion of the funds to support this effort could be taken from the existing exploratory or advanced development budget (e.g., 6.2 and 6.3A categories) and should be allocated by mission areas. The remainder of the needed resources could be obtained by departing from our traditional way of doing business. For example, I recommend that we eliminate Milestone I and, once a mission need is approved, decentralize management to the project manager level to bring the best alternative(s) forward to a full-scale development decision at Milestone II. This would allow additional flexibility and would permit the formerly advanced

development funds (6.3B) to be applied to approved mission needs. In addition, the elimination of the administrative workload for the Milestone I decision would save the considerable time (estimates vary up to 10 months) and funds associated with the current extensive schedule and administrative burden. Finally, I would recommend addition of another Milestone "X" (not 10) with one purpose—the elimination of projects for whatever reason (cost, schedule, performance, and/or supportability). Milestone X would consist of *independent* evaluators *not* in the development chain and would be controlled by the user community (preferably people rotated in from field units). Milestone X could be applied at any time during the life of a progam. A decision to institute a Milestone X would be made by the Chairman JCS (OSD mission areas) or the appropriate service Chief of Staff (service mission areas)—not political appointees. Funds saved would go to the appropriate service to be applied to the most pressing material needs (either new starts or improvement of existing systems). The program analysis/evaluation, operational, and logistics people in each service and OSD would make up a part of the Milestone X team.

In sum, the services' recent experiences with A-109 early in the acquisition phase have indicated a need for a better way to acquire, manage, and schedule front-end resources. Under current policies, when a generalized mission need has been approved, the service must attempt to break out and support resources without having identified a specific system. This has the effect of jeopardizing funding at the various budget reviews. In addition, the evaluation of a number of different concepts at the front end extends the development schedule and requires additional funding. In essence, the institution of A-109 has had the opposite effect from its intended purposes by the lack of support for funding such efforts and the extended time required to initiate a new start. The possible remedies offered above are simply ideas at this stage, but should be explored if we are to maintain a policy that will greatly improve competition and innovation in the systems acquisition process. ||

49 Subsystem Prototyping for Better Weapon Systems

Lieutenant Commander Stuart C. Karon, USN

Navy weapon system acquisitions are handicapped by the lack of a strong and efficient subsystems-oriented advanced development research program. A creatively managed 6.3A program to conduct concept evaluations, technological feasibility demonstrations, and critical item testing would provide needed risk reductions for major system acquisition and a continuing flow of subsystem improvements to existing fleet systems.

The primary reason for this deficiency is the lack of a single point of control, a "sea-daddy" for subsystem advanced developmental projects. With no one in charge, current efforts lack purpose, continuity, and integration into a synergistic whole. A "who's-in-charge-here" syndrome permeates the advanced development community as budgets fluctuate and the scope of efforts is changed continually to accommodate these perturbations. A mentor for these projects would ensure that a more level and reasonable continuum is maintained.

It is current financial management practice for the sponsor of advanced development programs to inflate out-year estimates of funding requirements. The project supervisor must justify these figures by imaginatively inventing a program with supportive rationale. The real intent of these high out-year funding levels may be to provide a management reserve for major programs that develop cost problems. Mere reprogramming or restructuring is all that is required to provide a funding transfusion from an advanced development technological feasibility demonstration to an ailing major program. With an emergency money supply available, major program managers have little incentive to stay within their budgets. Since pure 6.3A projects may not have specific items as end products, the cost of such reprogramming and restructuring appears to be cheap, as there is no obvious slippage in initial operational capability into the fleet.

The management reserve nature of 6.3A projects requires the advanced development project supervisor to respond to continually fluctuating funding profiles. He must scope his program into working and funding blocks that may be put together in any combination to match prospective funding levels. These combinations are changed often in the program objectives memorandum. Sound advanced development contracting and acquisition strategies are not possible in this atmosphere of constant change. Contracting, from planning to signature, is a 12-month procedure at best. Fluctuating program funding levels do not allow for sound contracting strategies as the program scope is always expanding and contracting.

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There is a growing awareness among the weapons systems planners of the importance of 6.3A projects. Concept validation and feasibility demonstrations are seen as necessary baseline work for future systems. The advanced developers are seen to require a reasonable and consistent funding level to do the required groundwork to meet future requirements. Since defining requirements for 10 to 15 years into the future is difficult, there is a natural tendency among program sponsors to concentrate on present systems and subsystem improvements that can be easily and immediately implemented into the fleet. While the spirit may be willing to invest in the future, the flesh becomes frustrated at determining and justifying what will be required, and instead concentrates on the present. This inward-looking philosophy is natural for senior officers who have alternated between billets as force-level and system planners, and fleet users. Operational deficiencies in the fleet become well known to these result-oriented men who transfer to Washington with a desire to effect immediate improvements in current systems. The awareness of important advanced development efforts wanes as 6.3A funding becomes an enticing pool of money that a program sponsor may utilize for his own pet programs or a major, high-visibility program in financial trouble. The lack of one specific research and development focal point with funding responsibility keeps advanced development projects from maturing at the most optimal pace considering costs, schedule, and technical performance and risks.

The irony that user- and result-oriented weapon system planners should trade future benefits for real-time gains is that subsystem prototyping incumbent in 6.3A projects is predicated upon close working relationships with the fleet. New ideas and techniques are functionally implemented using existing and commercial equipments and tested at sea during developmental testing periods and actual fleet exercises. Critical items and new technologies may be tested on a subsystem basis to reduce risk and help determine what is achievable for future systems. In both cases close working relationships between laboratory and contractor developers and fleet personnel allow for early and inexpensive evaluation of system utility, and consideration of human factors into the development. Fleet recommendations may be easily and most cheaply implemented at this early stage. Future capabilities may be more accurately predicted and tailored to meet evolving requirements as they have been pretested on a subsystem basis during actual exercise and operational environments.

In today's Navy systems acquisition environment, major weapons systems are often deferred until new ship developments are begun. Major system sponsors find they must belly up to the shipbuilding funding faucet to get support for their programs. When new shipbuilding programs are undertaken, there is insufficient

time to develop the new weapons suites they require. These ships are often commissioned with marginally capable weapons systems incorporating minor, subsystem evolutionary improvements. An aggressive subsystem prototyping advanced development program would reduce risks otherwise inherent in revolutionary new systems and allow the inclusion of most current technologies and capabilities. These systems must push against the boundaries of today's technology if they are not to be obsolete in tomorrow's environment.

The 6.3A project supervisor must be able to plan on a reasonably consistent funding profile. Significant gains may be achieved with a very modest investment in subsystem advanced development prototyping if there is funding continuity. Only by placing these 6.3A projects in the hands of a single focal point can the continuity of effort and funding be maintained to ensure that the U.S. technological advantage is maintained and future systems will be able to meet evolving requirements. ‖

Budgeting for Test and Evaluation

52

Henry H. Mendenhall

The role of test and evaluation (T&E) within the Department of Defense (DOD) has become increasingly important as the weapon systems and equipment procured by DOD have increased in complexity. The importance of T&E was emphasized in the early 1970s with the issuance of DOD Directives 5000.1 and DOD Instruction 5000.2, and 5000.3. DODD 5000.1 and DODI 5000.2 established the milestone procurement concept by separating the acquisition process into discrete decision milestones (Defense Systems Acquisition Review Council [DSARC] reviews). At each of the four major milestones, the progress of a given program is reviewed and, based on this review, a decision is made on whether or not to continue the program or modify its direction. DODD 5000.1 stipulates that T&E is to have a major input to the decision process at each major milestone. DODD 5000.3 links T&E to this milestone process, identifies the phases of T&E, and emphasizes the need for T&E "to assess and reduce acquisition risks and to estimate the operational effectiveness and operational suitability of the system being developed."

Due to the importance of T&E in today's acquisition environment and the attention that it is receiving at the Secretary of Defense and congressional levels, the program manager must place special emphasis on the planning and budgeting of an effective T&E program. The development of a program office budget for T&E is discussed below.

T&E Planning

Before proper budgeting and control can be implemented in a T&E program, planning must be accomplished to define the what, where, how, who, and when of the test program. This planning effort is facilitated by the preparation of the test and evaluation master plan (TEMP) required by DODD 5000.3. The TEMP is the controlling management plan that defines the T&E program and, as such, contains the integrated testing requirements, schedules, and resources required to accomplish the test program.

Proper T&E planning and preparation of the TEMP begins early in the program acquisition cycle and forms the basis for the initial test program cost estimate. The question of what is to be tested can best be answered by careful review of the work breakdown structure (WBS) of the system. Since a test program usually involves testing of component parts of a system as well as the total system, use of the WBS is a necessary function to accomplish proper planning.

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Once the test items have been identified, how will they be tested? The answer to this question will vary greatly, depending on the type of equipment involved. The T&E is usually tailored at this point to concentrate on the risks inherent in the program. An objective is to plan for unknowns and provide reasonable cost and schedule slack to minimize later impacts on the schedule and planned program budget.

Defining who will conduct the tests and where they will be conducted is also important for the development of a test plan and budget. Costs of testing will vary greatly depending upon the choices of test personnel, sites, and facilities.

Proper planning of a test program must be coordinated with a number of organizations and individuals to assure adequate coverage of all aspects of the T&E program. These organizations include the contractor, field activities, and test-range organizations, functional and T&E groups within the service, the user organizations, the operational T&E group that will be conducting the operational tests, and related OSD offices.

The final question to be answered for the planning phase is when will the tests be conducted? A detailed test schedule must be developed which identifies all test program milestones. During the development of these schedules, it must be kept in mind that the main purpose of testing is to identify problem areas. As much slack time as is reasonably possible should be allocated for proper correction of these identified problems and other unknowns. This is extremely important because the test schedules must be firmed up several years in advance to permit budgeting for the effort. Any slip in this planned schedule can seriously impact the entire program schedule and costs.

Figure 1 identifies the three major T&E categories as they relate to the four program phases and DSARC milestones. The DODD 5000.3 defines the three major T&E categories: development test and evaluation (DT&E), operational test and evaluation (OT&E), and production acceptance test and evaluation (PAT&E). All in-house and contractor testing during the development and production of a system can be categorized within these three types of testing. An important thing to note is the time relationship between the testing and the four program phases. This will become important later as we finalize the T&E budget by identifying appropriation categories.

A well-prepared and coordinated TEMP is the end result of this early planning phase of the T&E program. It is this plan which should form the basis for the T&E program cost estimates.

T&E Cost Estimating

After a detailed test plan has been defined, the next step in developing the pro-

gram T&E budget is defining the elements of the T&E program for which the program office is responsible for funding and estimating the time-phased costs to accomplish the tests. OPNAVINST 3960.10 states:

> The DA [Developing Activity] will plan, program, budget and fund the costs of all resources identified in the approved TEMP . . . for all T&E through DT-IV and OT-IV except fleet travel and operating costs for fleet RDT&E Support, OPTEV for travel . . . [specifically], (1) All DT&E costs, (2) All OT&E costs for OT-I through OT-IV, (3) All PAT&E costs, with exceptions noted above.

Using this as a guide, the program officer, in coordination with related test activities, can identify his T&E funding responsibilities.

The next step is to prepare estimates of the identified T&E elements. This process is like any other estimating process where the type of estimate will depend on the amount of information available on similar types of testing. Regardless of the type of estimating method used (e.g., parametrics, engineering), all elements of the test program must be considered: personnel, test facilities, test equipment, instrumentation, test beds, simulators, data reduction, documentation, spares, fuel costs, test units, expendables (e.g., target drones), and test-range facilities. Proper coordination with the test facilities and the contractor are again important at this point to obtain cost estimates that are as accurate as possible. Management reserve is an important consideration. In recent years, for example, the unforeseen increases in the cost of fuel have substantially increased operating costs of test vehicles and aircraft. This item alone has caused serious budget problems for a number of programs.

Once the cost estimates and time-phased funding profiles have been developed, the final phase in preparing a T&E budget can begin.

T&E Budget Preparation

Final development of a T&E budget involves allocating the time-phased cost estimates to proper budget appropriation categories.

As its name implies, research, development, test, and evaluation (RDT&E) funds are used for T&E purposes. However, not all T&E activities use RDT&E funds. Referring back to Figure 1, it is evident that some test activities extend beyond what is normally considered the R&D realm into the production phase. The allocation of T&E costs to the various appropriation categories is best defined in DOD Manual 7110-1-M, *DOD Budget Guidance Manual*. Figure 2 summarizes some of the more important criteria for classifying T&E costs. The figure is intended as a guide and by no means includes special exceptions and

criteria that apply to the cost classification process. For more detailed definitions and policies, refer to the DOD manual. An important point to remember is that the T&E program will not be funded entirely from RDT&E appropriations, but will also, under certain circumstances, utilize procurement and operation and maintenance (O&M) funds.

Once the estimated T&E costs are identified with the right appropriation, the result is a T&E budget that shows by fiscal year the amount and appropriations required for the T&E program.,

Summary

Preparation of a T&E budget requires detailed planning, scheduling, and cost estimating to be effective. This activity must occur early enough in the program (by Milestone I, if possible) to permit entry into the budget cycle in a timely manner. This early planning requires projection of a test program several years into the future with very little insight into the problems that may be encountered during the tests and which will tend to lengthen schedules and increase costs. The situation is further compounded by the fact that RDT&E budget estimates must be prepared on an incrementally programmed basis. This means that only those funds required for work in a given fiscal year are to be included in the budget request for that fiscal year. There is some flexibility in this regard owing to the fact that funds authorized for RDT&E have a 2-year term of availability. This, however, is closely controlled within the services. The Navy works with a self-imposed 15-month obligation period and the other services, 12 months. Extensions to the obligation period require approval at higher levels within each service and the program manager runs the risk of losing the funds. ||

Program Office Role in Budgeting for O&S Costs

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Bruce A. Block

Calculating and budgeting for operating and support (O&S) costs are two essential steps in integrated logistics support (ILS) planning. These processes may seem mundane when compared to other facets of the overall program, but if not performed accurately or in a timely manner, the system's initial operational capability (IOC) may be delayed, or the system may not be supportable in the field.

This paper will address two facets: actions taken by the PM during the life-cycle phases with regard to O&S costs, and the PM-user interface that must exist before accurate O&S cost estimates can be developed. The PM-user interface will also address the O&S cost information the PM must provide to the user, information necessary to enable the user to have resources available to support the new system.

Prior to the discussion, the definition of O&S costs is in order: "O&S costs include those costs associated with operating, modifying, maintaining, supplying and supporting a weapon/support system in the DOD inventory."[1]

During the life-cycle phases of a system, the program management office (PMO) performs certain actions to calculate and budget for O&S costs. In the conceptual phase, the logistics support analysis (LSA) data, which includes O&S costs, is of a general, parametric nature. Efforts are directed toward identifying problem and cost-driving areas in existing systems. No budgeting action is taken at this time with regard to O&S costs.

In the demonstration-validation (DEM/VAL) phase, the LSA effort addresses feasibility studies in conjunction with and correlated to technical feasibility studies. The effort is directed toward conducting design vs. support trade-off decisions before design is finalized.[2] Calculation of cost is accomplished based on parametric and engineering estimates. Budgeting may be accomplished for logistic studies or specific logistic problem areas.

In the full-scale engineering development (FSED) phase, general logistics support requirements are identified. Costs are calculated based on experience gained during DEM/VAL, contractors' estimates, and information from the user. The first budgeting actions should be accomplished for long lead items, providing budgeting information and overall systems information to the user.

The production-deployment phase results in a refinement of previous calcula-

1. "Uniform Budget/Cost Terms and Definitions," Department of Defense Instruction Number 5000.33, 15 Aug 1977.
2. "Acquisition and Management of Integrated Logistics Support for Systems and Equipment," Department of Defense Directive Number 5000.39, 17 Jan 1980.

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tions and budgets. Costs are calculated based on test results from FSED, user input as to force structure, and contractor/government planning estimates. Budgets are refined and the unknown areas reduced as better planning information becomes available.

Before discussing the PM-user interface, it is necessary to clarify the budgeting responsibilities of the PM and the user. The PMO is responsible for budgeting for the acquisition, development, and production/support items peculiar to his system. The user also has budget responsibilities for the new system for such items as user facilities, training, repair parts, common support equipment (stock funded), etc. The difference is that the PM budgets to acquire the system and place it in the Army inventory, whereas the user budgets for costs associated with purchasing from the inventory and supporting the system. The key is that the PM and user must be cognizant of their requirements and work together.

Now let's focus on the PM-user interface and key areas frequently overlooked by the PMO. These key areas that drive O&S costs are not funded by the PM, but by the user. If these areas are not accurately calculated and budgeted for by both the PMO and user, fielding is usually delayed or the system cannot be properly supported. It is essential that the PMO recognize and address these areas in a timely manner to ensure the user has the necessary information to program and budget for new systems.

Throughout the discussion, examples relating to specific systems are used. The illustration is not for the purpose of pointing out who was right or wrong, or finding fault with participant performance, but rather to show the intricate, complex tasks the PM and user face in fielding a weapon system.

The key areas requiring PMO-user interface are as follows:

Facilities

New systems which require the user to provide new facilities create many complex problems. First, the PMO must identify, ideally 6 years before IOC, facilities requirements to the user. This allows the user to go through the normal process to obtain funds and to acquire real estate (if necessary) to build and accept new facilities. Four years is the minimum lead time for acquiring facilities. Thus, the PM must determine facility requirements as soon as possible. The PMO must also recognize the military construction, Army (MCA) funding constraints faced by the user. For example, U.S. Army, Europe, is limited to $300 million per year (new construction). Some programs have been deferred to FY 84–85 as previous FY ceilings have been reached. In addition, the PMO requirements must compete with other user requirements, such as modernization of existing facilities, other new systems, and quality of life issues (child care centers, recreation facilities). Finally, there is congressional pressure to reduce U.S. construction overseas in favor of NATO sharing a greater portion of the construction burden. This has caused some projects to be ranked low in the NATO funding structure, delaying facilities for new systems. Some specific facilities issues the PMO should

be aware of are as follows:

HOUSING

Will the introduction of the system, when combined with other new systems at a given location, result in a requirement for additional housing (troop billets, family housing)? The PMO must identify the increase/decrease in personnel associated with the system.

MAINTENANCE

Are additional or modified facilities required to support additional vehicles, increased size or weight? The PMO must state maintenance facility requirements at each level of maintenance. Example: A new generation of signal intelligence/electronic warfare (SIGINT/EW) systems was being fielded overseas. The PMO representataives briefed the field 10 months prior to IOC. When questioned about general support (GS) maintenance facilities requirements, it became obvious the question had not been addressed. The field was not able to provide GS repair facilities for the equipment and, at best, would have facilities 3 years after IOC.

AMMUNITION STORAGE

Any new system that requires ammunition storage must state requirements as soon as possible. Existing facilities overseas are at capacity because of increased ammunition requirements, the increase in size of new munitions replacing old systems (Stinger for Redeye, Viper for Law). A long lead time exists to obtain land for ammunition storage owing to environmental and political pressures.

RANGES

New weapon systems have increased firepower and range. Training areas in many cases cannot accommodate this increased range or provide training for complex weapon systems. As an example, the infantry fighting vehicle (IFV) requires a range on which the vehicle can fire in a 360-degree fan simultaneously to allow firing through the firing ports. Training areas will require larger safety fans, laser-safe ranges, and more complex firing courses. The PM must identify these unique and complex requirements for the user.

Training

The new equipment training (NET) concept must be developed early and provided to the user. This allows the user to program personnel and funds to support both the initial and follow-on training. This also includes such training costs as fuel, TDY, and training ammunition. For example, a tracked vehicle PMO briefed the field 6 months prior to IOC. A picture of the vehicle showed smoke grenade launchers on the vehicle. This was the first the user knew of this capability. As a result, no funds were programmed or budgeted to purchase training am-

munition (smoke grenades). Since the smoke capability was new to the infantry, it was imperative this type of training be conducted.

Initial Repair Parts Stockage

The PMO must be cognizant of the user's repair parts needs at the organization level (prescribed load list, PLL), direct support (DS)/general support (GS), and GS base.

The structure for repair parts support and flow must be understood by the PMO, so that the proper level and quantity of parts required can be developed. Example: The SIGINT/EW representative had developed repair parts stockage and resupply for using units at the GS maintenance level. They did not realize that GS maintenance units do not provide repair parts resupply.

Timing of initial repair parts stockage is critical. Retention of parts is based on receiving a specified number of demands in 1 year. The start of this 1-year period must be carefully selected to avoid early deletion from stockage. Example: An electronic system comprised of high-dollar printed circuit boards and components was scheduled for fielding in 1977. Repair parts were shipped to all units. For some reason the IOC was slipped 15 months. When the end item was finally fielded and repair parts were required, there were no parts in stock. The computer had classified all parts excess (no demands in 12 months) and the parts (value $190 thousand) had been turned in.

Support list allowance cards (SLAC) decks are recommended stockage lists. Since the SLAC decks are seldom system-peculiar, users are requested to screen the deck and identify stockage requirements. Proper education is required as the user will overstate the requirement, exhausting existing stocks. Example: The M240 machine gun stated no PLL was required and only six lines were required at DS level. However, the user, familiar with high parts consumption on the M239 machine gun, requisitioned M240 stockage levels commensurate with M239 levels. As a result, the first units to requisition, requisitioned the entire Army inventory.

Recurring repair parts requirements must be identified so the user can include resources in budgets and PARR submissions. If not included, other operation and maintenance, Army, (OMA) areas will have to be reduced to meet the spares requirements.

Fuel

Fuel requirements must be stated as early as possible. Fuel storage and transport capability in overseas theaters are at capacity. To increase fuel requirements without providing additional capability will only degrade wartime capability of the system. Fuel supply structure and capability are not the PMO's responsibility, but the PMO must provide information so the user can program resources required.

Support Equipment

Support equipment includes government-furnished equipment and any other equipment that the user must requisition and/or fund. Items commonly included are trucks, generators, trailers, test, measurement, and diagnostic equipment, special-purpose equipment, and tool sets. Any support equipment the user must requisition (and provide OMA funds for) should be identified, and availability verified well in advance of IOC. Example: A tactical switchboard was being fielded which required a prime mover. The user was to requisition the vehicle; however, user requisitions were rejected as the vehicles were not available until 1984. As a result, the switchboard fielding was delayed until the PMO provided a portion of the vehicles required.

Transportation (Second Destination Shipping)

The PMO must provide quantity, expected delivery times, and delivery location. This enables the user to program resources (rail, highway, waterway) to clear port and utilize back haul. Any transportation restrictions (size, weight, special driver training) must also be clearly identified.

Personnel Requirements

The PMO must indicate impact on personnel strength. As in the United States, communities overseas operate under budgets based on population. Thus, any strength increases require increases in support funds (housing, utilities, facilities maintenance, etc.).

In summary, the tasks the PMO and user face in fielding a new system are complex and time-sensitive. All of these areas must be addressed if O&S costs are to be calculated and budgeted with a reasonable degree of accuracy. The PMO can ensure system supportability with adequate user resources at IOC by coordinating with the user early in the development cycle. ||

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Managing the IR&D Program in Defense Industry

Gunther E. Reins

Every major company must improve its products and develop new products to remain competitive and to grow. The costs of the associated research and development (R&D) are amortized over the projected sales volume, or some portion thereof, and are included in the sales price. Management must balance the R&D effort against the competitive implications of the added cost. Freedom to select and direct the thrust and direction of the R&D effort and flexibility to redirect in response to findings and/or environmental factors are absolutely essential to the development of a competitive market posture.

The R&D program is even more critical to defense industry because its products must be technically sophisticated to cope with a complex threat. The R&D program within defense industry differs from that in the commercial sector in two major ways. First, government regulations on allowable costs and profit ceilings influence, to a large extent, the capital available for company-funded independent R&D (IR&D) and the related bid and proposal (B&P) efforts. Second, the common "winner-take-all" nature of defense business, together with frequent shifts in emphasis and the attendant dynamic funding environment, introduces a high degree of uncertainty into the forecast sales which form the budget base for the company-sponsored IR&D/B&P efforts. Management of these scarce IR&D/B&P resources demands the same degree of attention as the management of major contracts, because today's decisions indelibly determine the future business posture of a company.

IR&D and the Business Development Cycle

IR&D is the ongoing, company-sponsored technical effort in (1) basic and applied research, (2) development, and (3) systems and other concept formulation studies. It focuses on advancing the company's technology base, improving current products, and developing new products in response to anticipated future military needs.

B&P is the company-sponsored effort directed toward satisfying a current military need. It includes costs incurred in preparing, submitting, and supporting solicited and unsolicited bids and proposals, studies, design calculations, computer modeling, system concept formulation studies, and prototype or model construction.

The future business development cycle (Figure 1) is initiated on the basis of internal mission-area analysis, intelligence studies, and marketing information on

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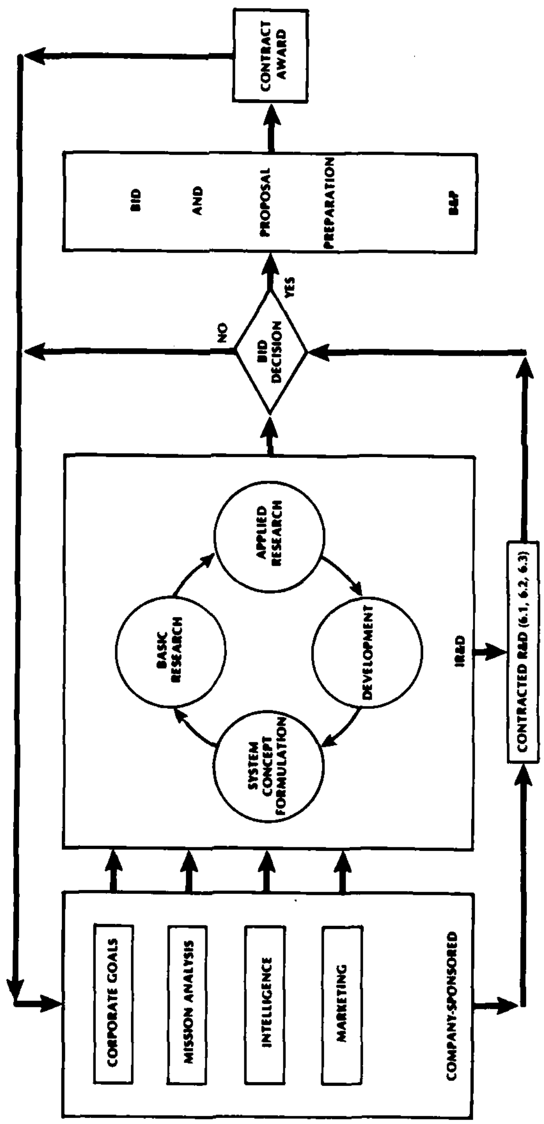
FIGURE 1
Business Development Cycle



customer requirements. Mission-area analyses, in conjunction with system/concept formulation studies, identify new technology needs. IR&D funds are devoted to basic and applied research to resolve technology issues. Development of key components or subsystems follows. The payoff of the research and development is assessed in systems and concept formulation studies.

The IR&D effort is closely monitored by management and redirected, as necessary, on the basis of results of the ongoing IR&D projects, new marketing inputs, customer information, and management direction. As the technology matures, the government is solicited for funded R&D support to further advance the technologies and/or study the utility and effectiveness of these new technologies in a weapons systems context or other military application.

As the need for a military system emerges, the company assesses the realities of a new start (real requirement and funding), the applicability and maturity of its related R&D projects (both company-sponsored and government contracts), its competitive position, and the available resources to make a preliminary "bid-no-bid" decision. With a bid decision, a carefully paced B&P effort is initiated, which is continuously revised to reflect significant new inputs on the in-house business situation, competition, and government developments. A final "bid-no-bid" decision is made after receipt and review of the RFP. A positive decision will culminate in a proposal. If successful, booking of a new contract will provide sales which, in turn, will provide the budget base for continued research and development.

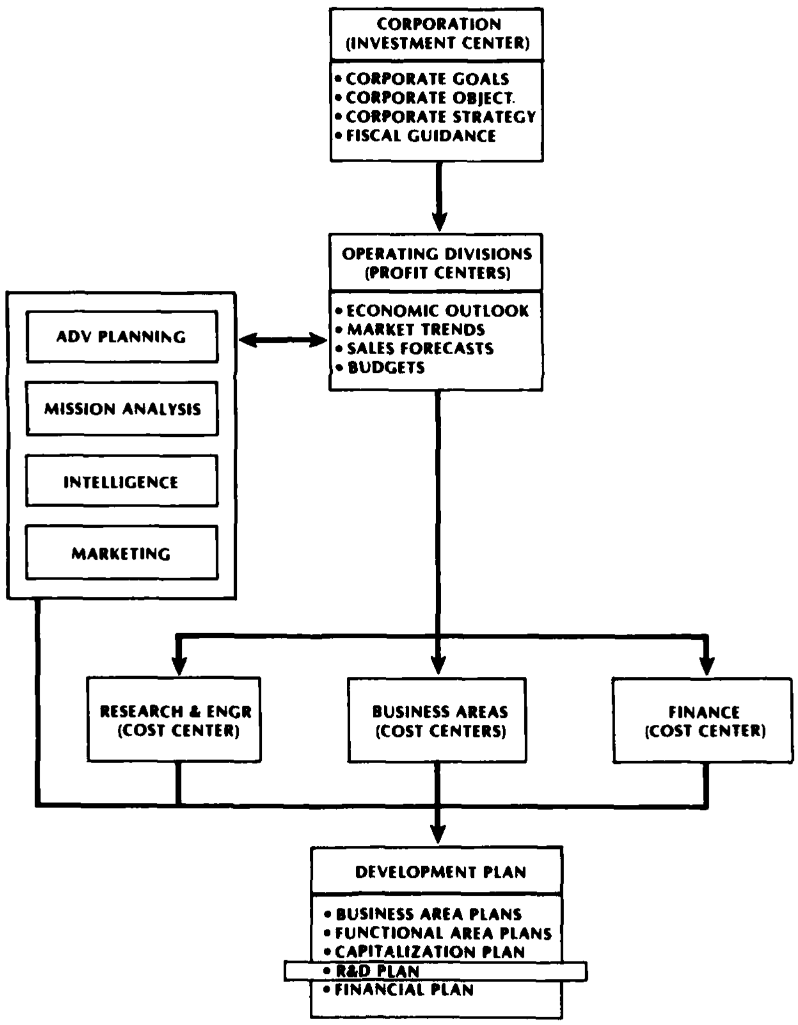
A "no-bid" decision at any time calls for re-evaluation and possible redirection of the IR&D program.

Planning and Programming the IR&D Effort

The defense industry planning/programming process involves the whole corporate structure (Figure 2) and resembles the DOD planning/programming process to some degree. Planning is conducted at the corporate level (investment center). Corporate staffs develop and provide corporate goals, objectives, strategies, and fiscal guidance to the operating divisions (profit centers).

Programming is performed at the operating division level and approved at the corporate level. The yearly programming process begins with an examination of economic, political, and market trends. Business potential and new markets are evaluated in terms of available dollar volume, the addressed market, competition, relevant technical experience, and investment requirements. Yearly sales forecasts are developed for each business/product area and categorized as firm, near firm, identified new business, and unidentified new business. General and applied research and technology development necessary to support the projected

FIGURE 2
Planning and Programming the IR&D Program



sales are identified, and associated IR&D/B&P investments are developed and spread over time (by year). Future business potential and projected return on IR&D/B&P investments are used as yardsticks for setting priorities between and within business/product areas. Required IR&D/B&P funds to develop the forecast sales must be reconciled against projected IR&D/B&E budgets generated by the projected sales through iteration and prioritization.

The programming effort culminates in the issue of a planning document, sometimes known as the development plan, which charts the course for the operation division for the ensuing 2-10 years. This plan is built around the corporate goals, objectives, strategies, and fiscal guidance, and identifies time-phased, integrated IR&D/B&P efforts, manpower and skill needs, capitalization, and funding levels to advise the forecast sales.

Financing the IR&D Program

IR&D and B&P costs are partially recoverable from the government when advanced agreements have been negotiated on a dollar ceiling. Recovery is usually made through a charge included in the G&A overhead rate applied to all company sales. The remainder is financed from retained earnings.

To be eligible for partial reimbursement, every company which received more than $2 million for IR&D/B&P (or profit center which received over $250,000) in a year, submits an annual technical brochure that fully documents its planned IR&D program. The technical problem to be solved, the objective, the approach, the programmed funding, and the progress to date must be documented for each project and submitted to the government. The military application and quality of each project is evaluated by the government and a ceiling on allowable IR&D costs is established for the next fiscal year. The company also prepares a B&P plan. The government reviews this plan and establishes a ceiling on allowable B&P costs. Provisions in the Defense Acquisition Regulations allow interchangeability of IR&D and B&P funds as long as combined ceilings on costs are not isolated.

The ceiling for the total IR&D and B&P costs averages about 5 percent of sales for major defense contractors. Small companies can recover in excess of 10 percent of sales on IR&D costs alone.

Contractors do not receive direct payments for incurred IR&D and B&P costs; rather, they recover an amount up to the negotiated ceilings by including the allowable costs as a factor in the G&A rate.

Executing and Controlling the IR&D Program

After appropriate adjustments to the IR&D/B&P plans for changes in the

negotiated ceilings, the plans are implemented. Typically, funds are placed under the control of the marketing organization and released periodically (quarterly) through a formal process to department heads, managers of business/product or functional areas, or cost account managers, who are held accountable. These individuals, in turn, issue task orders or work packages for discrete items of work. Many contractors use their internal cost and schedule control systems for control of the IR&D/B&P effort because it provides the visibility necessary for continuous, close evaluation and redirection of the character or scope of the task.

Conclusion

Good management of the IR&D program is essential to the security of the country. The advanced technology base developed through the IR&D program (1) permits development of technologically sophisticated products, (2) allows effective retrofit or product improvement of existing military systems and equipment, (3) reduces technical risks of new products, and (4) shortens weapon development time. ||

67 Determining Contractor IR&D Budgets

Thomas F. Szelag

Independent research and development (IR&D) is contractor technical effort not sponsored by contract, not required in the performance of a government contract or grant, and not required for the preparation of a specific bid or proposal. The categories of tasks performed are basic and applied research, concept formulation studies, and product development.

IR&D is a normal business expense for all technology-based companies, whether or not they do business with DOD. All such companies must also maintain active in-house R&D programs if they are to respond to changing customer needs. Contractors who do government work initiate and direct IR&D programs under policies established by DOD and other government agencies. The overall DOD intent in supporting IR&D is to encourage the evoluation and maintenance of a strong and creative industrial base from which DOD can draw, as needed, both new concepts and rapid responses for its military requirements. DOD's support of industry IR&D programs complements the support from the laboratories each service has for research and development. Specific objectives supporting this intent include:

—accessibility of technically qualified contractors willing and able to compete for technically oriented DOD contracts

—reduced costs, through availability of competitive technical options in filling operational needs

—superior military capabilities derived from competitive technical options originated by IR&D work

In addition to supporting a company's technical capability, DOD supports companies in responding to government requests for the application of existing or new technology through bid and proposal allowances. Bid and proposal (B&P) costs are those incurred by any company in preparing, submitting and supporting proposal efforts—successful or not—for any contract. The tasks include the administrative effort directed toward preparing the proposed document and assembling the cost and management data. In addition, there may be some technical effort undertaken specifically to support a contractor's bid or proposal, such as concept studies or "brassboard" modeling of a concept.

The major difference between IR&D and B&P is that IR&D funds are not directed toward or tied in any way to a specific proposal. IR&D normally precedes a related B&P effort. It is longer range, is generally broader in scope, and is intended to lead to technological development for future business. B&P ef-

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fort refines the IR&D results and applies them to specific proposal requirements.

DOD Instruction 5100.66 states the policy for recovery of costs incurred by the contractor in IR&D effort. The directive reflects DOD's recognition of IR&D/B&P as a necessary cost of doing business, especially in a high-technology environment, and establishes a framework for the management of IR&D.

IR&D/B&P costs are recovered as a part of the indirect costs allocated to all contracts, both government and commercial, regardless of contract type. The amount of R&D recovered on DOD contracts is limited by advance agreements or by formula. In either case, the portion of DOD work in the allocation base is the major factor. IR&D costs are normally accumulated in a general and administrative (G&A) indirect cost pool and charged equitably using the government-agreed-to base. Commercial and non-DOD government contracts each bear their share of the total allowable cost.

IR&D/B&P costs are limited by the use of the following:

—mandatory advance agreements with contractors recovering from DOD more than $2 million in IR&D/B&P costs during the prior year;

—ceilings determined by formula for contractors not required to negotiate advance agreements;

—special provisions in individual contracts that limit or exclude IR&D by making such costs allocable, but not allowable.

Advance Agreements

Any company receiving payments in excess of $2 million from DOD for IR&D and B&P during its fiscal year is required to negotiate an advance agreement with the government establishing a ceiling for allowability of IR&D and B&P for the forthcoming fiscal year. Advance agreements may also be negotiated at a contractor's profit center that recovers more than $250,000 in IR&D and B&P. The costs under the $2 million or $250,000 criterion include only those recoverable IR&D and B&P costs allocated during the year to all the company's DOD prime contracts and subcontracts. All costs include full burdening, the same as if the IR&D and B&P projects were contracts, except that G&A is not applied.

Part of the advance agreement process requires the contractor to submit technical and financial data to support this proposal and initiate the negotiations. Failure to reach an agreement by the end of the fiscal year results in reduced reimbursements for the forthcoming year. Failure to submit a proposal results in zero payment for IR&D and B&P.

The financial data required includes total sales, DOD sales, the ceiling limitations for the previous 3 years, the amount of IR&D/B&P costs incurred, and the

amount of costs allocable and recovered in those years. It must indicate how the costs were allocated by contract type—cost, fixed-price, or other. The proposed ceiling for expenditures for the following year is expected to be a normal extension of the previous proposed and actual expenditures with growth added. In making an evaluation of the proposal, the contractors are also expected to incur actual costs above the ceiling of the previous year. This is to show that the contractors are interested in promoting and preserving their technological standing in the competitive arena. The contractors also submit annually a technical brochure to the Tri-Service Negotiation Group—the technical evaluators for DOD. These brochures are received by the IR&D Data Bank, a centralized computer-based information source at the Defense Technical Information Center. It contains data on each IR&D project described in the contractor's technical plan. The data bank is used by each DOD component in supervising its R&D programs.

The DOD directive requires annual evaluation of contractor-submitted technical plans to evaluate the technical quality of his IR&D program. In addition, at least once every 3 years, the evaluators make an on-site review of the technical work. Upon receipt of the analysis from all the activities, the service negotiator prepares the government position in terms of negotiation objectives and strategies for each contractor.

TEG Establishes Criteria

An IR&D Technical Evaluation Group (TEG) was formed to establish criteria, methodology, and quality ratings of contractor IR&D programs. The TEG designates the lead military department for each contractor and provides guidance and procedures to the Defense Contract Administration Service for negotiation agreements. The technical evaluation of a contractor's programs assures that technical work is properly categorized for reimbursement purposes. A determination of which work is relevant to potential DOD needs is also made. The technical quality of the contractor's programs are evaluated for potential use as one factor in determining his ceiling. The technical evaluation also serves to establish and maintain technical communication between the government scientists and engineers and the IR&D investigators, in addition to providing the contractor with an independent assessment of his program.

Contractors having programs of good technical quality, containing a high percentage of projects relevant to DOD needs, normally are compensated at a higher rate than those with mediocre or poor technical quality or lesser relevance. This technical evaluation also provides an incentive for the contractors to improve their programs for future DOD requirements and also provides a degree of guidance by the government. Standard evaluation forms simplify the evaluation

procedures and minimize the time required.

The factors considered by DOD in reviewing contractor IR&D programs to determine reasonableness of costs include a 4-year historical review and 1- to 3-year projections of the following data:

—IR&D costs
—B&P costs
—Sales
—Product line information
—Allocation base data
—Mix of contracts
—Customer mix
—Burdening procedures

Other data considered include:

—Departmental budgets
—General business trends
—Prior-year estimates vs. actuals
—Technical evaluation
—Prior history of contractor ceilings compared with competitors

Financial Planning Data

Financial planning data are usually available from contractors from 3 to 6 months prior to the start of a contractor's fiscal year. Firm budget data is not generally available until 30–60 days preceding the fiscal year. Summary statements of IR&D and B&P technical objectives are available at the same time as the financial data. This data is used in the negotiation of budgets for the forthcoming year. The negotiation process, however, can result in reimbursement being partially based upon the effectiveness and tenacity of the contractor's negotiation.

There is no clear consensus on the utility of IR&D. The Department of Defense and others close to IR&D within the government and industry support it fully and insist the benefits are real and cost effective. Those in positions of review endorse the program after careful review. Independent reviews question part or all of the current IR&D program. A personal opinion is one of support for the existing program format and the belief that real benefits are to be gained from IR&D. Naturally it takes many years to realize the benefits. We all need patience. ||

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The Work Breakdown Structure as a Budgeting Tool

Lieutenant Colonel Walter L. Busbee, USA

The concept of a work breakdown structure (WBS) comes from the field of systems engineering. The systems approach continues to exert great influence on our methods of considering problems. Further, it guides us as we delineate or quantify those aspects of a problem about which we need more knowledge. By dividing labor into task-related segments in a WBS, we can apply resources, which can then be tied to costs. Where there are costs to be estimated or aggregated, the budgetary process is active.

> A work breakdown structure is a product-oriented family tree composed of hardware, services and data which result from project engineering efforts during the development and production of a defense materiel item, and which completely defines the project/program.[1]

While this definition is system- or hardware-oriented, the WBS concept has a broader historical base. It has wider applicability than just the world of acquisition management. In dividing the work to be done, whether the setting is a feudal tribe or a modern program management office, the basic premise applies—a structured approach helps to allocate tasks and account for outcomes. A command operating budget, based on either organizational or functional lines, uses the WBS methodology in a non-product-related venture.

Discussion

As DOD looks for ways to provide more accuracy and responsiveness in its budget process, several questions merit attention. The WBS system has added discipline to the planning and execution of major projects. What is the practical limit of refinement of the WBS and further utilization as a budgeting tool? A fundamental question is, "Should we attempt an extension given the premise that it is always possible to refine a structured system by merely going to greater detail?"

CURRENT PRACTICES

Currently, provisions can be made for undistributed budget to cover situations of a temporary nature where it is not practical to define work and distribute the budget in detail. That portion of the budget not assigned to elements of the

1. Department of Defense MIL-STD-881A, Work Breakdown Structures for Defense Materiel Items, 25 April 1975.

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contract WBS at a specified level is called undistributed budget.[2] In a similar vein, cost accounts (budgets developed for specific WBS elements) account for far-term efforts (6 or more months in the future) by allowing for less discrete planning packages, eventually to be converted to near-term work packages. Both of these practices illustrate that practical limits do exist on the use of the WBS as a budgeting tool.

NEED FOR CHANGE

Continuing scrutiny of the DOD budget mandates that efforts to estimate and control costs be strengthened even more. Strength in the budget process does not necessarily correlate directly with greater detail or complexity. The GAO recently reported on DOD efforts to control costs. In its focus on the design-to-cost concept, which is crucial to effective budgeting in the out-years, the GAO stated that there was: "Failure to develop the cost data base needed to establish cost-performance estimating relationships relevant to design-to-cost objectives, goals, and decisions."[3]

The WBS method of identifying cost accounts and collecting data from them at the component/subcomponent level affords the opportunity to upgrade the cost data base for both cost-estimating and budgeting purposes.

The new DODI 5000.2 addresses the WBS as a management information system in this way:

> A realistic work breakdown structure that is limited to the minimum number of levels necessary shall be developed for each program as a framework for planning and assignment of responsibilities, reporting progress, and as a data base in making cost estimates for other systems.[4]

The focus seems to have changed slightly with the deletion from the old DODD 5000.2 (January 1977) of the specific reference to using the WBS in making *future* cost estimates of *new Defense* systems (deleted words emphasized). The implication is that the WBS need not be restricted to future cost estimating for new systems only. A more contemporary application to near-term budgeting efforts may be in order. If this interpretation is correct, then DOD recognizes an uptapped potential in the WBS as a change agent.

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2. Department of Defense C/SSR Joint Guide, Cost/Schedule Management of Non-Major Contracts, 1 November 1978, pp. 4-8.
3. GAO Report PSAD 80-6, Impediments to Reducing the Costs of Weapon Systems, 8 November 1979, p. 33.
4. DODI 5000.2, Major Systems Acquisition Procedures, para E5a, 19 March 1980.

WBS APPLICATIONS

The WBS system provides a logical sequence of breaking down a task in the manner in which it must actually be performed. It also provides structured data for cost collection. Establishing the WBS at too low a reporting level can cause distortions and difficulties in accumulating and reporting contract information.[5] When properly structured, budgets are distributed in accordance with cost and schedule control system criteria rules, and an accurate estimate of total project costs can be attained. This procedure excludes indirect costs at the work-package level of the WBS. Therefore, the limitation on the WBS system as a budgeting tool is apparent. It cannot be used to plan (forecast) all expenditures at the subcomponent level. What modifications are feasible or appropriate to facilitate the use of the WBS as a comprehensive budgeting aid?

Developments in the cost-estimating field provide some clues about the possible outcome of a top-down approach inherent in the WBS method. Cost estimating is an essential step in budget formulation. Many "cost analysts believe that greater accuracy can be achieved by estimating airframe program cost (as an example) in a lump sum rather than as a sum of several subordinate cost categories."[6] This is because of the difficulty of segregating recurring and nonrecurring cost impacts in developing cost-estimating relationships. A similar problem exists in the allocation of indirect costs using a WBS approach to cost estimating. Budgets formulated from either approach are subject to such perturbations.

A HYBRID APPROACH

There are several areas for further study in improving the use of the WBS as a budget tool. Where a detailed and reasonably stable WBS can be established early in a project, it is clear that an industrial engineering estimate will provide the best cost data for budgeting purposes. The bottoms-up approach furnishes an auditable product, which is not always the case when cost-estimating relationships are used. However, a WBS estimate is usually not appropriate for new developments involving risk and uncharted areas.

A better basis for budget formulation, in the form of accurate cost estimates early in the life cycle of a system, would yield great dividends. The RAND studies have concluded that the development of cost-estimating relationships at level 2 of the WBS (or lower), with subsequent aggregation to get a total system estimate, yields mixed results. A hybrid approach which combines elements of the cost-

5. OASD (Comptroller), C/SCSC, The DOD Cost/Schedule Control Systems Criteria, revised February 1978, p. 19.
6. RAND Report R-1693-1-PA&E, Parametric Equations for Estimating Aircraft Airframe Costs (Santa Monica, Calif.: RAND Corp., February 1976), p. 8.

estimating relationship and industrial engineering (e.g., WBS) approaches, may be an area for further research. Reams of data are available on *actual* development costs of major components in a WBS of typical systems. This data should be easily retrievable from past cost performance reports. Where it is known that similar components will be used in a new system development, efforts should be tested to merge cost-estimating relationship results with known costs from the major component level of a WBS. If enough firm estimates of component costs can be attained in this manner, the degree of uncertainty in the remainder of the total cost estimate can be addressed. A detailed examination of this hypothesis is beyond the scope of this article, but it is evident that innovation is needed to restore credibility to DOD's cost-estimating and budgeting processes.

Summary

The WBS is an important budgeting tool. Its application to non-system budgeting tasks is well established. It is founded on the principle of dividing the work to be done, and then aggregating sub-unit costs up the budget chain on either an organizational or functional basis. It is also a valuable tool when applied to fully matured hardware systems. The extension of the WBS approach to cost estimating and budgeting of new-systems development is not established. Current practice leans heavily on the cost-estimating relationship approach during early stages of a project. Additional study is needed to determine if it is feasible to refine the WBS methodology for use as a budget tool earlier in the systems acquisition process. ||

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Reducing the Bow Wave in Defense System Budgeting

Lieutenant Colonel Michael J. Goldstein, USAF

An examination of defense budgets (available dollars and their use) over the past 10 years reveals a striking and disturbing pattern. Constant-dollar budgets have remained relatively stable, while purchasing ability has steadily decreased. Further, the demand for new systems (and replacement of obsolete equipment) has far outstripped available funds.

Faced with the problem of too much demand chasing too few dollars, defense decision-makers have devised a management scheme for the situation. Using this elaborate prioritizing and allocating system (PPBS), decisions can theoretically be made for the "best" use of the limited available funds. The decisions as to which systems to buy theoretically cut off the purchase of those projects of less importance or utility.

In practice, however, the theoretical decision process has not worked. Rather than cancel lower priority programs, the approach has been to *spread available funds* thinly over a *great number of programs.* Rather than fund a few for efficient production rates, many are carried simultaneously at low, inefficient rates.[1] Programs are then stretched out by this process, leading to yet higher unit and total program costs owing to production inefficiencies and compounded inflation.[2]

Adding to the problem of the stretch-out of in-production programs is the attempt to bring into production more new systems coming out of development. This year-to-year increase in demand, under a management scheme which tries to do a *little of everything* (and do each at the peak of technical excellence and performance), merely aggravates the stretch-outs and compounds out-year problems. On a graph of demand overtime, the picture is bleak.[3]

Another view of the problem is revealed when the funds demand for current systems (those now in production or in full-scale development) is examined. The total production cost estimate (development estimate) for these systems is $560

1. G. K. Smith, "An Overview of Acquisition Policy Effectiveness," Rand Study WN/10435-DR&E, February 1979, p. 21.
2. Hq AFSC Study, Feb 1979, as reported in presentation of Hq USAF/ROCS on the Defense Science Board 1979 Summer Study; HQ USAF/ROCS letter, 29 Nov 1979, Defense Science Board Recommendation on Program Stability.
3. OUSDR&E (Acquisition Policy) presentation at the 8th Annual Acquisition Research Symposuim, 3 May 1979.

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billion. Assuming a 30 percent cost growth before completion,[4] this cost can easily rise to $725 billion. If an arbitrary 10-year production period is assumed during which production will be completed, funding of $72 billion per year is required. This is twice present levels! Further, completing current programs in production will not take 10 years, nor are systems now in full-scale engineering development planning on production through 1990. The real problem in the 1983–88 period is therefore much worse than the 2:1 factor. Even if the problem were limited to merely replacing present inventory equipment to maintain a constant force level, program costs will exceed available budgets by about 40 percent.[5]

The bow wave is thus a complex interaction of forces. It starts with very high-cost, high-technology systems, and a demand for inventory which exceeds available funds. It becomes aggravated by increased costs for the systems (relative to their development estimates) as changes are made, better estimates reveal actual cost more accurately, and higher than expected inflation occurs. The acquisition approach then slows down the planned production rate, while adding to each program's total cost and lengthening its out-year demand for funds. The projected funds needs thus are pushed higher and higher in future years owing to the stretch-outs and entrance into production of yet more systems.

Solution

It appears a threefold attack must be made if the bow-wave problem is ever to be managed. First, there must be an increase in the budget; second, there must be a reduction in demand for new systems; and third, there must be acquisition measures to hold to the projected costs for systems which do enter production. No one of these approaches alone will solve the problem, and the failure to apply one will undermine the effect of the other two.

The need for added funds is recognized by defense decision-makers and the Congress. Recent world events have revealed the weakened state of defense forces as a result of living with inadequate budgets spread thinly for stretched-out procurements in prior years. Despite the quality of the new equipment, its limited quantity and the simultaneous retirement of worn-out inventories have left a net force too small to meet the threat.

A reduction in the insatiable demand for new systems presents perhaps the most challenging problem. Given the reduced state of present inventories and the

4. Statement of Jerome H. Stolarow, Director, Procurement and Systems Acquisition Division before the House Committee on Government Operations Subcommittee on Legislation and National Security, United States General Accounting Office, 25 June 1979.

5. USDR&E paper presented by Dr. Paul Berenson to the Defense Science Board 1979 Summer Study on Unit Cost.

sophistication of potential enemies, the need for more *and* better is overwhelming. Demand, however, must be tempered by economic reason. We must set quality levels necessary to meet the threat rather than the best levels technology can conceivably yield. Simplified systems, and life extension of current systems vice new items must be taken more seriously than the lip service presently given. A reversal must begin in the trend to replace obsolete equipment with systems using technology to do more. Technology must be used instead to replace worn-out items with *like* items capable of being produced more cheaply. Additionally, demand must be tempered with forceful decisions that limit acquisition to those systems of greatest need, within real budget constraints, and at production levels of practical efficiency, rather than continuing to attempt to produce a little of everything at once. The 1979 Defense Science Board *Summer Study on Unit Cost* indicated some awareness of this need to alter demand, but whether it will, in fact, lead to changes is very uncertain.

The final leg of the attack on the bow wave comes from acquisition measures which hold system cost at originally estimated levels. The measures are in a number of areas. Realistic cost estimates are needed. Demands for changes during development and production must be constrained, and technological "opportunities" shunned. Program stability must be introduced to avoid fluctuations and stretch-outs, with their subsequent impact on cost. Of course, if added funds and reduced demands become reality, the need to juggle rates and stretch programs will be greatly relieved. Unfortunately, at present inventory levels, even if some hard decisions are made, it seems unlikely they will genuinely reduce demand in all quarters.

A great problem with the way we do business is the turnover of decision-makers. Even if present top defense managers and congressional leaders make appropriate decisions to require only selected systems, their successors have no restraints forcing them to live with the prior choices. The temptation is too great to initiate something else and, rather than cancel the prior effort, to reduce it and stretch it out. The only tactic that appears feasible to control this instability is a multiyear commitment that is both difficult and instantly costly to undo. A number of approaches have been suggested recently to rectify this problem. They include multiyear contracting and multiyear appropriation.

Both approaches are unfortunately doomed to failure in the present environment. First, they or any other stabilizing approach cannot succeed unless the other major parts of the bow-wave attack occur (funds and reduced demand). Second, even with the other parts, these methods of achieving stability are, by themselves, impractical. Multiyear contracting puts the PM (or the service, where approval comes at that level) in the position of creating a contingent liability for

instability without a concomitant commitment by Congress. Even if congressional approval is obtained, such as relief of the $5 million cancellation ceiling for the program, no permanent congressional commitment is made. Multiyear appropriations, by providing all production funds for total system requirements in a single fiscal year, would require a total revamping of the budgeting process. It is inconceivable that Congress would appropriate the entire MX, XM-1, or Trident program production funds in one year and essentially shut down production of everything else that year. Would the services take turns getting the total annual production budget?

The only practical approach mentioned to date to obtain a multiyear commitment would be a multiyear *authorization* for a stabilized program, and supporting language in the annual appropriations act. The authorization would serve as standing statutory approval for the program at its stabilized level. The appropriation act would establish, by statute, a congressional requirement to maintain production at the stabilized rate and for supporting budgeting and appropriation actions by the Department of Defense and Congress respectively. Though this approach would not remove all flexibility (prior laws can be repealed), it makes instability difficult and provides a positive show of congressional support. Only the factors of inflation or other necessary changes would result in variation in the funding established by the initial (and subsequent) appropriation statutes.

Summary

The bow-wave problem is real and getting worse. It represents indecision over the past years in conjunction with insatiable demand for both quality and variety. If this situation continues unchecked it can only lead to buying less and less at ever higher unit prices. Sufficient out-year budget relief to resolve the problem is unimaginable. However, with some budget relief and the use of strong-willed decisions, the trend can be reversed. Primary among the needed decisions is a willingness to live with less performance and less variety. Further, a commitment to stability must be made by both DOD and Congress. The latter can commit via authorization and appropriation statutes for particular programs. Such action will also eliminate the fickleness of the former, which stabilizes this year and juggles the program next year. ||

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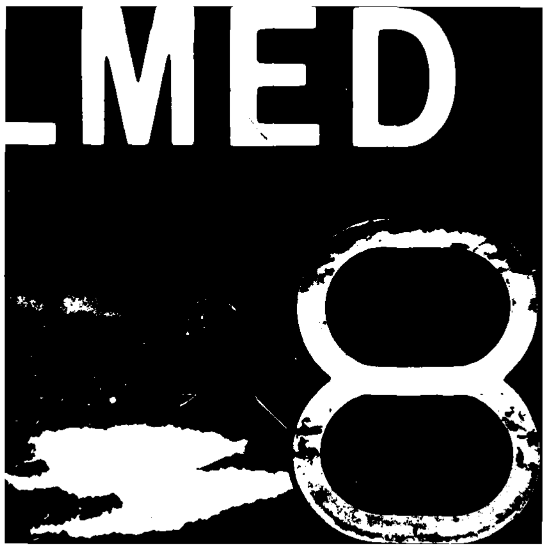
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